X Miscellaneous

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SHORT OBSERVATIONS

Rt: ON THE Storry

Principles and moving Powers

ASSUMED BY THE PRESENT

SYSTEM of PHILOSOPHY.

49

——— Atlas en ipſe laborat,
Vixque ſuis humeris labentem ſuſtinet axem.

By an IMPARTIAL ENQUIRER.

LONDON:

Printed for W. NICOLL, in St Paul's Church Yard,
and T. SLACK, in Newcaſtle. MDCCLXIV.

[Price One Shilling and Six-pence.]

BRITISH MUSEUM

PREFACE.

THERE *is no doubt of it,* truth *is a moſt excellent thing, and worthy of all the encomiums beſtowed upon it: It is cloathed with all the excellency that can poſſibly be aſcribed to it. But then, when we deſcend to particulars, it is no eaſy matter to determine what is the* truth. *Such things are ſelf-evident and obvious to our ſenſes, tho' they may be conſtituted truths by forming them into propoſitions, yet they are generally conſidered as facts, from whence other no leſs certain, tho' leſs obvious, concluſions may be inferred. It is ſuch certainties as theſe that firſt aſſume the name of* truth. *But ſuch truths are only known to thoſe who make the diſcovery, or who have examined and tried the* ratio *which leads to the concluſion.*

The rational powers of man are beſtowed upon him to be his pilot either in diſcovering ſuch truths, or in examining the evidence and certainty of ſuch as are diſcovered to him. That man's reaſon then, muſt be far gone in a lethargy, who truſts his veſſel at ſea to the ſteerage of another. The uſe of our reaſon in diſcovering *truth, may well enough be compared to a voyage; but it is a navigation which every one muſt perform for himſelf, for as one man cannot manage the courſe of two ſhips at the ſame time, ſo one man cannot take the ſteerage of another's underſtanding. He muſt then have either a ſturdy faith on the infallible capacity of his neighbour, or a mighty indifference about the iſſue of the voyage, who, in ſearch of truth, can venture himſelf a paſſenger with another pilot at the helm.*

If therefore I were to define truth, *I would call it,* That which requires all that ſcrutiny and examination in order to diſcover it, which it will ſtand the teſt of by examination: *Or,* what no man can be poſſeſſed of, but he who has ſearched for it, and tried it. *Notwithſtanding all this wiſe and plauſible* ipſe dixit *of mine, I don't know how it happens, but ſo it is, that tho' mankind are univerſally agreed in profeſſing the moſt pious and inviolable regard for truth, yet ſuch generally is the nature of their zeal for it, that they cannot bear to have it canvaſſed. It is very uncommon for people to eſteem that ſo precious which is ſo cheaply come by; for learning what we hold for truth, often coſt us no more than taking up with the moſt common accounts, and the ſum of our evidence is, that no body doubts it; or the ſanction of an authority, which we muſt be permitted to preſume, all mankind owe an undiſputable allegiance to.*

It would not be an eaſy matter to perſuade people of this ſtamp, that they are the greateſt enemies

enemies to what they profeſs the warmeſt friendſhip for. Yet there are ſtrong preſumptions, that principles which coſt people ſo little are not always infallibly true; and I need go no futher, for an example and proof of it, than obſerve, that among ſuch it is received as a certain maxim, that whoever is ſo audacious as to examine any doctrine they happen never to have doubted of, muſt be in a groſs error himſelf.

It is not eaſy to account for a turn of mind ſo common among men, unleſs it is, that we have naturally a paſſion for being religious *and* wiſe, *to which two all knowledge may be referred, or at leaſt eſteemed ſo, at as ſmall coſt to ourſelves as poſſible. Or perhaps there is an uneaſy blank in the mind of man, while unpoſſeſſed of certain* principles, *which either ſupineneſs or more important engagements won't permit it to ſearch for; therefore, it lays hold of the firſt which are offered to it, as neceſſary conveniences, not becauſe they furniſh it with any waking entertainment, but as they accommodate it with pillows and cuſhions for the repoſe of the drowſy underſtanding.*

With all this there is one unaccountable thing not uncommon among men, which is, that you ſhall find numbers of redoubted champions often entering the liſts in the defence and ſupport of the honour of truths that they never examined. It had been well for ſuch knights that they had previouſly beſtowed ſome little pains in getting acquainted with their profeſſed dulcinea. *They would not have entered the liſts with ſo many wind-*

windmills; they would have ſpared her the mortification of many of the exploits performed in the pretended defence of her excellency; and they would have ſaved themſelves from many an outragious combat and diſaſter, in which her honour was no more concerned with their danger, than the divine legation of Moſes *is with the deſcent of* Æneas *into hell.*

One cannot ſufficiently applaud the benevolent intentions of the worthy Lord Shaftſbury, *who commiſerating the misfortunes, and unlucky circumſtances, which the adventurers in controverſy were frequently expoſed to, pointed out a good-natured facetious way of eſtabliſhing truth, and overthrowing error, which might hurt no body: For who would be offended, nay who would not be pleaſed to ſee another indulging himſelf in one of the innocent and inoffenſive* pleaſures of imagination. *But the misfortune is, ſome people will always be miſtaking things, and I dare ſay his Lordſhip would be very ſorry to ſee the bad ſucceſs of his ſcheme, and the folly produced, both among his friends and foes, by their miſapprehending his meaning: The one ſide fooliſhly imagining that their own laugh was a teſt of truth to themſelves; and the other exclaiming that ridicule could never be a teſt of truth, becauſe they themſelves could not bear it. But certainly ridicule is an excellent teſt of truth, and both it, and they who are ſo happy as to ſearch for it and find it, will ſtand that teſt with much the ſame firmneſs, as pillars of marble or gates of braſs would ſuſtain the ſhocks of men who were ſo wiſe as to eſſay beating them to pieces with their heads.*

But it may be ſaid, what is all this to the purpoſe of the following ſheets? Why truly, perhaps not much. It muſt be owned there are many ſubjects of ſuch ſmall importance to mankind, that it cannot much affect their true happineſs or intereſt, whether they know them, are ignorant of them, or labour under miſtakes about them. However, leaſt I ſhould be ſuſpected of intending under this character to imply a general reflection upon ſubjects of learning; I profeſs to be of opinion, that there are no ſubjects of ſo little importance as to be unworthy of examination: And, as every deciſion upon any ſubject acquires a dignity by bearing the name of a truth, *we owe ſo much reverence to that name, as to enquire into, and defend or reprove the application of it, as we ſhall find cauſe.*

But as there are ſome who think that the ſubject of world making, is one of the moſt ſublime ſtudies and employments of rational minds here, and muſt conſtitute their greateſt happineſs hereafter, I am under no apprehenſion of falling under any imputation on account of my ſubject: And every thing conſidered, I cannot be blamed for fortifying myſelf againſt the power of authority, by zealouſly enforcing the danger of admitting its weight in the eſtabliſhment and propagation of truth. One has not ſo much reaſon to be afraid of ridicule, conſidering that they may be allowed to laugh without taking offence, who give themſelves very little trouble either to think or ſpeak, to the purpoſe I mean, upon any ſubject.

There is one thing further to be ſaid in favour of ſcrutinies into ſubjects, however little their importance may be apprehended to be of, which is, that a man cannot learn to reaſon ſtrictly and juſtly, unleſs he accuſtom himſelf to ſearch and enquire upon every ſubject however uninterreſting. Unleſs a man count it his honour to diſcover truth in ſmall matters, without leaning to authority, falſe honour will ſometimes prompt him to reſiſt the brighteſt evidence of it when propoſed to him by argument. Therefore, I conclude it is a prudent maxim for people to accuſtom themſelves to ſearch and examine, without the awe of authority in the leaſt caſes, that they may not be miſled, nor have their faculties dulled thro' want of exerciſe, when matters of the greateſt importance come to be propoſed to them.

As I think it might prove no unuſeful improvement of the plan of Reviews, *and ſuch like publications, and would ſave the undertakers of theſe works a good deal of trouble upon ſome occaſions, if authors were to draw up an abridgement or ſummary of the plan or argument of their productions, within a limited compaſs proportioned to the ſize of the work, I ſhall preſent the reader with an example of this kind. However ſmall any work may be, ſuch an abſtract may prove very convenient to many readers on another account, which I ſhall give in words of* Martial.

Lemmata ſi quæris cur ſint adſcripta, docebo:
Ut ſi malueris, Lemmata ſola legas.

§ I. *Inſiſts on the inſufficiency and inconcluſiveneſs of natural Theology, becauſe no deciſive argument ever has been adduced, nor indeed can be, which fairly proves, that either the materials of the univerſe, or the frame of it, are an* effect, *or in other words, had a beginning. This argument is urged in ſeveral different lights; and while this is the caſe, it is further alledged, that no preſumptions of wiſdom, thought, or deſign, manifeſted in nature, can document there is a Supreme Being abſolutely diſtinguiſhed from nature, in whom only theſe powers reſide. The wiſeſt of the old philoſophers, who confined themſelves to the lights of nature and reaſon, never could go higher than a ſoul of nature, or of the world; and in fact, that doctrine is ſtrengthened by the hypotheſis of theſe philoſophers who introduce the immediate agency of a firſt intelligent cauſe, always exerting itſelf in the courſe of nature; which conſequently eſtabliſhes the ſame connection between it and that cauſe, as is underſtood to be between ſoul and body in men and beaſts.*

II. Space *is aſſerted to be a mere negation, which has no poſitive properties of its own that can reach our ſenſes or mind; and it is alledged unfair to aſcribe to it any properties which matter only can impreſs us with the ideas of. In this ſection alſo ſome reflections are offered on the infinite diviſibility of matter, by which it is alledged, the philoſophers can only mean the diviſibility of the ſpace matter occupies, tho' they at the ſame time teach, that ſpace is indiviſible or inſeparable,* *which comes much to the ſame purpoſe. Alſo a pretty cogent argument is urged againſt* infinite diviſibility *in any ſenſe, drawn from the relation mathematics has eſtabliſhed between diſtance and power.*

III. *The properties of matter, or theſe generally aſſigned to it, are diſtinguiſhed into three kinds, and claſſed in a manner, it is hoped, no perſon will have any objection to.*

IV. *The firſt axiom of the preſent philoſophy, or the* vis inertiæ, *is conſidered. Reſt and motion are maintained to be ſuch oppoſites, that it implies a contradiction to ſuppoſe an equal diſpoſition to either inherent in the ſame body. The one is maintained to be a poſitive, which neceſſarily implies power or momentum; the other a mere negative, which implies no power or momentum in any direction. From the very ſuppoſition of creation, it is argued theſe diſpoſitions cannot be equally natural to matter: Alſo, from the conſideration that all natural life, and all mechaniſm depends on motion, and not on the inherent properties of matter, it is argued, that motion muſt be ſomething ſuperadded to matter, and mechannically ſupported in it. Some preſumptions are alſo offered in favour of a plenum, which indeed the ſupport of motion by mechaniſm only, neceſſarily implies.*

V. *Is intended to prove, that matter containing in itſelf no momentum of any kind, it can give no reſiſtance to any impreſſion upon it, nor can it continue to exert the effects of that impreſſion;*

preſſion; and therefore the ſecond axiom or general law of motion, or rather the natural ſymptoms and phenomena from which it is deduced, muſt ariſe from the relations all matter we know any thing of ſtands in with the ſyſtematic compoſition of the univerſal frame of nature.

VI. *Conſiders the third axiom of the preſent philoſophy, and demonſtrates that the re-action of matter entirely depends upon gravity; conſequently if gravity were ſubtracted, there can be no proof, nor even a ground of preſumption adduced, that bodies would exert either reſiſtance or re-action. If that is the caſe, all the axioms of courſe fall to the ground, or inſtead of being abſolute laws, become mere phenomena depending upon other cauſes; which cauſes it is incumbent upon the philoſophers to look for. The ambiguous and evaſive terms in which ſome philoſophers chuſe to expreſs themſelves in, where all the ſymptoms of proper reſiſtance appear, is likewiſe remarked upon.*

VII. *From the defined nature of the projecteile power, the author endeavours to prove it can never ballance the power of gravitation, which has oppoſite or merely negative properties, ſo as to maintain the motions of the planets. It can never cover its momentum when it is reſiſted, whereas gravity can: Therefore the conſtant bending of its direction, which muſt be equal to a conſtant proportionable reſiſtance, muſt uniformly and perpetually weaken its power and ſtrengthen that of gravitation; ſo that the direction of motion muſt inevitably fall more and more, and at laſt* *wholly into the direction of gravitation.—From hence the author maintains, that no power acting upon an orb, in a direction towards its centre of motion, can maintain its projectile motion in the direction of circles; and that no power but a ſimply reſiſting one can do it.*

VIII. *Even upon the ſuppoſition that the properties of theſe powers were ſimilar, that is, equally retained their propenſity to motion tho' reſiſted, the author alledges, ſuch powers could not move the planets in elipſes, becauſe in the ſame proportion that the one* vis motrix *gains power over the other, in the ſame proportion does it gain in altering the tendency of motion towards it own direction; and no properties of figures or reaſoning from them can explain, how, when a quantity of motion, and alſo of inclination, is gained by gravitation over projection, the orb will, while theſe remain unchanged, leave at any point the direction of the moving power that prevails, and recede into the direction of the weaker power; or* e contra. *The author alſo examines the phenomena of an experiment produced to illuſtrate the motions of the planets by the abovementioned powers.*

IX. *From the mathematical proportions of the* momenta *required between gravitation and projection (which the author alledges ſhould be nearly equal) in order to carry the orbs about in nearly circles, it is maintained theſe two powers cannot be the cauſe of their motions. Here the author's reaſoning reſts principally upon the relation of the diagonal to its paral-*

parallelogram, and he alledges by comparing the commonly aſſigned different momenta *of theſe two powers, the* ratio *of gravitation is not ſuch in proportion to projection, as to bend the direction of the projected body ſenſibly from the right line.*

X. *After propoſing ſome of the intricate difficulties which attend the doctrine of abſolute and relative motion, and offering two conſiderations towards ſolving them, the application of the doctrine of abſolute motion to the ſatellites is examined. Upon this the author argues, that the motion of the moon along with the earth, can neither be owing to her gravitating towards it, nor to a projection impreſſed upon her along with the earth: Becauſe ſhe has a projection of her own round the earth; and ſhe cannot be ſo projected as to move in two different orbits at one and the ſame time, by the* vis inertiæ *continuing on projectile motion round the ſun, and another round the earth. From whence it is concluded, that the motion of all the planets muſt be momentarily guided either by mechaniſm or a ſpiritual power.*

XI. *Examines the firſt lemma of Sir* Iſaac Newton's Principia, *and ſhews, that in order to accommodate mathematics to the ſuppoſed powers of projection and gravitation, he fairly and expreſsly reverſes the doctrine of infinite diviſibility, in other reſpects maintained by himſelf and all the mathematicians.*

Tho' I had been ſufficient for the undertaking,
which

which I am far enough from preſuming to be, it would have been fooliſh enough to have undertaken an examination of the mathematical demonſtrations by which that great man adjuſts the phenomena of the celeſtial motions to the principles he aſſumes, until the natures, powers, and proportions of momentum aſſigned to each of theſe moving principles, were firſt fairly diſcuſſed. However, as an ingenious gentleman communicated to me the fallacy which he thought couched in the firſt lemma of Sir Iſaac Newton's Principia, *I have taken upon me to annex his demonſtration of it, as an inſtance how the moſt ſubtile mathematicians may ſlip into very palpable inconſiſtencies. This I ſay, without any intended diſparagement to the exalted genius of Sir* Iſaac Newton. *It may be ſaid of the greateſt mathematicians, without the leaſt detraction, as was ſaid of the greateſt of poets:* Aliquando bonus dormitat Homerus. *But one cannot help making a mortifying reflection upon the imperfection of the mathematics, as well as of all other ſciences, or rather upon the imbecillity and limited compaſs of the human mind in all its ultimate reſearches; when at the ſame time we find the firſt principles of mathematics, aſſuming, and even demonſtrating the doctrine of* infinite diviſibility; *and at the ſame time find the philoſophical lemmata of one of the greateſt mathematicians ever exiſted, neceſſarily implying a denial of the ſame doctrine.*

It has been complained of, that no writer hath appeared againſt Sir Iſaac Newton, *or the preſent philoſophy, who has not inſiſted upon the* *term* attraction, *as implying ſome mutual tendency eſſential to matter, or ſome charm or unknown virtue by which it is affected: But in refutation of this, Sir* Iſaac Newton'*s writings are appealled to, even as early as his letters to Mr* Boyle, *in proof that he never meant by attraction, bodies moving towards each other, without being impelled or acted upon by other bodies, or by any other powers of whatever kind. The following obſervations are founded upon no ſuch exceptions to any terms uſed by the preſent philoſophy, but upon the natures or properties aſſigned to the powers, their relations and proportions, and the impoſſibility of adjuſting theſe to the motions they are ſuppoſed to produce.*

However, if I were freely to ſpeak my mind, I cannot ſay the complaint is juſtly founded. " Poſſibly, ſays a very great and highly reſpec-" table apologiſt for Sir Iſaac Newton, *ſome " unſkilful men may have fancied that bodies " might attract each other by ſome charm or " unknown virtue, without being impelled or " acted upon by other bodies,* or by any other " powers of whatever kind."——*That I dare ſay no perſon was ever ſo unſkilful as to ſuppoſe; and by the addition of that ſentence, the truly valuable author himſelf ſeems to intimate his own uncertainty as well as Sir* Iſaac Newton's, *as to the nature and the cauſe of theſe powers; whether they are material or mechanical, that is, bodies acting upon bodies; or ſpiritual, that is,* any other power of whatever kind: *For we have no comprehenſion of any power but one or other of theſe; nay, we may ſafely venture to pro-*

pronounce, there can be no other power in the univerſe but one or other of them. But if the power which cauſes attraction or any efficacious properties in bodies is not material, but may, for ought we know, be produced by any other power of whatever kind, then no perſon can be blamed for calling ſuch power, God,—ſome unknown virtue, or a mutual tendency eſſential to matter. It comes to one and the ſame thing, if it is not material, and we don't know what kind of ſpiritual power it is.

There is no queſtion Sir Iſaac Newton *has ſignified he thought that theſe powers might ariſe from the impulſes of a ſubtile ætherial medium, that is diffuſed over the univerſe, and penetrates the pores of groſſer bodies: But I do not think it was an unjuſt reflection, one formerly made upon this ſuppoſition, that it was only retiring a ſtep farther back into the dark. For it comes all to one, whether the cauſe of attraction be aſſigned to groſſer bodies themſelves, or the impulſes of a medium which penetrates them. If the powers of that ſuppoſed medium are unmechanical, they muſt be ſpiritual: And ſeeing the medium is only ſuppoſed, it is more natural to aſſign theſe unmechanical powers to bodies which we know diſpoſed to theſe motions; than to ſuppoſe bodies we do not know ought about, and then aſſign unmechanical moving powers to them.*

In ſhort, that objection againſt Sir Iſaac Newton*'s powers of motion, which is complained of, lies ſhortly thus: As Sir* Iſaac *ſeems not to have had*

had any notion of reſolving his axioms or relative laws of motion to mechaniſm, but on the contrary conſiders them as laws *(another word I apprehend for ultimate, ſpiritual or unmechanical power) the very ſame objection lies againſt his impelling etherial medium as againſt the term* attraction.

I ſhall only add, that Sir Iſaac's *ſuppoſition may be very properly urged with this additional deficiency. If his penetration carried him ſo far as to ſuppoſe ſuch a medium for the maintaining of attraction, gravitation, elaſticity, &c. How came he not to ſuppoſe that the ſame medium alſo might be neceſſarily concerned in ſupporting his axioms, the abſolute laws of motion, reſt, reſiſtance, &c. For the knot does not lie in gravitation or attraction, or any particular kind of motion, but in finding powers to produce and maintain motion in general.*

If theſe are mechanical, it is eaſy to ſuppoſe, tho' we ſhould never be able to explain in what manner, that the Contriver may have adjuſted the mechaniſm to produce all the tendencies of motion obſervable by creatures. But if they are unmechanical, laws, properties, or whatever we may call them, then there is no occaſion for ſuppoſing a cauſe of gravitation, or for taking it amiſs to have it called occult quality, unknown virtue, charm, law, or any word we have no meaning to.

I have only further to add, in relation to the ſubſequent obſervations, that the examination of many

many of them does not depend upon mathematics at all; and ſuch of them as do, may all be brought to the teſt of its very firſt principles and moſt ſimple propoſitions, without the leaſt need for having recourſe to theſe refined depths of geometry, into which few are qualified for penetrating. Theſe, no doubt, have their uſe, both in enlarging the powers of the mind by exerciſe, and in extending the compaſs of its knowledge upon ſubjects to which geometry can be applied: But it may be received as a ſelf-evident propoſition, That the moſt ſubtile refinements in any ſcience, can never overthrow, and in effect deſtroy, what the firſt and plaineſt propoſitions of that ſcience eſtabliſh. Yet there is nothing more certain than, that there is no ſcience in which men have been converſant, which has not been purſued the length of ſuch vaniſhing ſubtilties, as in a manner annihilated the moſt certain elements of all knowledge. How far Sir Iſaac Newton *falls under this cenſure, in reſolving the chord, the tangent, and the arc, into the* ratio *of equality in his* lemmata, *I ſhall leave with the judgment of the impartial.*

The principal intention of the following obſervations is, to ſuggeſt to the candid enquirers into phyſics, a fair examination and diſcuſſion of the following queſtions; without regarding the terms in which philoſophers affect to expreſs theſe things. Can there be any conceivable diſtinction between material motion and activity? Can we have any idea or conception of material power diſtinct from motion, or a conſtant niſus towards it? Is not continued motion then, a conſtant exertion

ertion of power? Is not power inherent in bodies, an active and not a paſſive property? Can motion be owing to any thing but an active principle reſiding in matter, if it can continue to move in ſpaces void of matter; for material activity and motion are the ſame? Subtract the niſus of gravitation from bodies, can we have any conception of any momentum diſtinct therefrom, attending them or reſiding in them, either moving or at reſt? If a body or planet have no inclination or tendency to the place it is in, can it have any reſiſtance to being removed to another place? Does not a niſus to reſt, or a reſiſtance in matter to change of that ſtate, imply in it a double contradiction; namely, a poſitive effort to do nothing, and, a ſuppoſition that without that niſus it would conceive ſelf-motion? Can phyſics demonſtrate, that a power (projection) *which totally loſes, and can never recover juſt as much niſus to motion as it meets with reſiſtance, can co-operate with another power* (gravitation) *which always retains its whole niſus to motion, however its actual motion may be ſuſpended or reſiſted, in perpetuating the motion of any body in a direction always common to ſuch powers? Where two unequal powers are concerned in the motion of a projectile, muſt not its direction be juſt as much inclined to that of the prevailing power, as the* momentum *of the prevailing power exceeds that of the weaker? When the direction is always ſo inclined, can mathematics demonſtrate that the weaker power can ever change the inclination of that direction? It is admitted, that the quantity of motion generated by the greater power might, at a given* *point, carry off a body from the direction it was inclining to, if the prevailing power could be ſuppoſed to ceaſe to incline the direction, at leaſt ſo much, and yet retain its momentum: But can that ſuppoſition be made? Can two powers, whoſe original or incipient* momenta *bear not to each other, in a ſecond or the ſmalleſt given ſpace of time, the proportion of one to* 10,000 *(I take a definite for a yet uncalculated proportion): Can, I ſay, powers ſo proportioned move any projectile in a circle, or in any curve figure, which returns into itſelf again? Can a body move in two abſolute motions, by the power of the* vis inertiæ, *or in two different directions at one and the ſame time? Or, can the weak inclination of one body tending towards another, at the rate of ſixteen feet in a minute, determine that body to conceive all the abſolute motion of the other, tho' projected from it at the rate of nearly a thouſand miles in the ſame ſpace of time.*

I have no doubt theſe queſtions will be carefully and impartially examined and reſolved by the Minority, *to whom the obſervations are moſt reſpectfully inſcribed, by*

The AUTHOR.

ERRATA.

Preface, *Page* 1. *Line* 7. read *ſuch Things* as *are*. *Page* 11. *Line* 27, *for* cover, *read* recover. *Page* 14. *Line* 25, *dele* at the ſame time.

SHORT
OBSERVATIONS
ON THE
Principles and Moving Powers
ASSUMED BY THE PRESENT
SYSTEM of PHILOSOPHY.

Of the Theology deducible from Philoſophy, unaſſiſted by any other Light.

ALMOST all philoſophers introduce the ſubject of Natural Philoſophy with a panegyric upon the utility of that ſtudy, as containing in itſelf evident and ſufficient demonſtration of the being and perfections of a Creator. Many declamatory volumes might be collected from the writings of philoſophers and divines upon this ſubject; but making proper allowance for the profuſion of rhetoric laviſhed out upon this article, we ſhall ſhortly weigh the arguments advanced in ſupport of it, which may all be comprehended under theſe two :

1ſt, Every effect muſt have a cauſe. *2d*, The works of nature in whole, and in every part, contain evident footſteps of wiſdom and deſign, as well as of power; which neceſſarily imply the exerciſe of an infinite mind, employed in eſtabliſhing the conſtruction and powers of nature.

As to the firſt, it is allowed that whereever we perceive an *effect*, a *cauſe* is neceſſarily implied: But in order to apply the argument to nature, it remains to be proved that it is an *effect*: This the philoſophers have hitherto overlooked ſo unaccountably, that they never yet, that I know of, have attempted it. When that ſtep is once gained, it muſt be allowed the argument will be immoveably eſtabliſhed. But the whole difficulty lies in fixing that point; and the difficulty appears to me ſo great, that I cannot perceive how it will be ſurmounted. When a man once acknowledges there is a God, he can rationally admit that works may be done by him, which are infinitely beyond our conception; but a man can never rationally ſuppoſe things beyond his own conception, in his progreſs of reaſoning towards the diſcovery or proof of a God or Creator. Man cannot prove there was a Creator, without firſt ſuppoſing that all things were once nothing; but bringing any thing out of nothing, and reducing any thing to nothing, are equally prerogatives of Infinite power; therefore it is abſurd to ſuppoſe the one, in order to prove the other; for it is in effect, ſuppoſing the very thing you engage to prove.

In other words, *being* and *nothing* (like good and evil, or light and darkneſs) are two irreconcilable oppoſites, and it is impoſſible for man to conceive they are convertible into one another. Every work of God implies, that the divine conception of it is as foreign and ſuperior to that of creatures, as his power is in executing it: And for a man to pretend to ſay, that he can conceive the poſſibility either of bringing *being* out of *nothing*, or of reducing *being* to *nothing*, is ſaying, he is endowed with the conceptions of God, but only wants his executive power. It is very ſtrange, that reaſonable creatures ſuppoſe the poſſibility of annihilation, in order to prove creation, when it requires the ſuppoſition of creation juſt as much, to prove the poſſibility of the annihilation of any thing.—To ſuppoſe an event, which it requires both an infinite conception and power to accompliſh, in order to lead a proof of the exiſtence of ſuch capacity and power, is confuſion.

Let us take the ſubject in another light: What carries in itſelf no marks of its coming to nothing, can carry no characters of its having once been nothing: What bears in itſelf no ſign of its diſſolution or ending, can bear no evidence of its having had a beginning: And what contains in itſelf no evidence of its commencement, can yield no intimation of its being an effect. Whether we apply this reaſoning to univerſal nature, conſidered abſtractly as matter, or complexly, as matter forming one vaſt incomprehenſible ſyſtem of activity and life, the concluſion is the ſame.

MEN's reaſon is generally blind on that ſide which flatters their own capacity; becauſe we have been informed, and accuſtomed to admit, of the poſſibility of annihilation, therefore we boaſt of it as a precious ſtone wrought out of the quarry of our own conceptions. The properties which characterize matter, ſuch as extenſion, ſolidity, figure, &c. imply no ſymptoms which can enable us to infer, or even ſuggeſt to ourſelves, the idea of their mutability, or of their ever failing :— Now if reaſon cannot poſſibly infer, from whatever we know of the conſtitution of matter, that it, or its eſſential properties, can become nothing or be annihilated; it muſt follow, that it is equally impoſſible for reaſon either to diſcover or prove, that nothing can become matter, or in other words, that the materials of the univerſe were created. Reaſon is fully authorized to determine, that whatever bears in itſelf the marks of its own diſſolution, has had a beginning; and the juſtice of this deciſion is confirmed by the mutability and decaying nature of millions of forms and modes of being; but as to the conſtituent materials of all forms, they carry all the marks of immutability that reaſon can deſire to acquieſce in; and what appears to be immutable, yields expreſsly the ſame evidence of being eternal.

We cannot carry our reaſoning one ſtep further, when we ſurvey the great complex frame of nature, the heavens and the earth, than we are authorized to do in regard to the materials of which it is compoſed. If we ſuppoſe, with Sir *Iſaac Newton*, that, along with its eſſential characters, matter is alſo poſſeſſed of abſolute properties, ſuch as the laws of motion, reſt and reſiſtance; and of relative ones, ſuch as gravitation or attraction, coheſion, repulſion, *&c.* which are the baſis of the conſtitution and powers of the whole: Theſe, whether they are God, virtues gone out of Him, which adhere to whatever paſſes thro' his hand, or inſeparably eſſential to the nature of material being, imply as little any ſymptom of their poſſibly decaying or being extinguiſhed, as the above properties of matter which characterize it, and which I called eſſential.

Further, all the vaſt and inexhauſtible fountains and powers of univerſal life, which depend on each other, and correſpond as cauſe and effect, bear as ſtrong and reaſonable marks of their permanent duration, as the materials employed in them do. Let ſome chimerical philoſophers ſuppoſe and imagine as they pleaſe, reaſon has not one ſolid ground of preſumption, that the ſun will by length of time, waſte and die out like a culinary fire, or that the ſtars of heaven will extinguiſh as dying lamps; that the vital air and liquid æther, which fill the expanſion of the azure firmament, will paſs away like the temporary ſuffuſion of a morning cloud; that the ſolid earth will be reſolved, ceaſe to keep her courſe, or prove barren to the genial influences of the ſun; or that the waters of the ocean will in time be drunk up, like the dews of the night. No, all theſe, for ought we know, or can know, upon the ſtricteſt principles of reaſon, are as durable and immutable as time and ſpace themſelves: And whatever bears all the marks of eternity without end, muſt neceſſarily, to reaſon, imply expreſsly the ſame evidence of eternity without beginning.

As to the ſecond argument, I ſhall only obſerve, that while it is impoſſible to determine the creation of the univerſe, either as to matter or form, by any philoſophical argument, the moſt conſpicuous footſteps of wiſdom and deſign in the frame of nature can only ſuggeſt, That that vaſt mind, and that immenſe executive power in the world, muſt be coeval, and related together in ſome ſuch manner as the powers of our body and mind are, ſo as to make one and the ſame being. This, tho' the faireſt and higheſt concluſion that philoſophy ancient or modern could ever attain, yields us no very reſpectable or reverential idea of that Infinite mind; for however ſublime views the ſtupendous grandeur of nature may give us of its abilities, the diſpenſations of fortune throw no light upon its moral agency.

Now I apprehend it is no unjuſt reproach upon the wiſdom of ſuch modern philoſophers as profeſs, by the energy of their own capacity, to diſtinguiſh ſo clearly between nature and the author of it; that by conſtituting Him the immediate agent of what are called its univerſal Laws, they connect him as intimately with the world, as a ſoul can be ſuppoſed with its body: And truly, the philoſophy which calls in the immediate agency of a Deity, as a neceſſary and eſſential part of nature, can never diſtinguiſh Him from nature; and as there are no traces of diſtributive juſtice to be found in nature, the lights of philoſophy can never make ſuch a perfection out in any being eſſentially connected with it.

In a world of uncertainties, where good and evil, virtue and vice, harmony and confuſion, happineſs and miſery, life and death, and all other contradictions, are undeniably blended together in an unconceivable perplexity; what can ſuch grovelling, bewilder'd capacities as ours infer? The moſt natural and juſt reflection that can occur to ſuch creatures, even after we are informed that theſe things are the reſult of Infinite goodneſs and wiſdom, is, that they muſt be intentionally wrapt up in darkneſs, in order to confound all our impotent pretenſions to penetration; and to reduce us to the mortifying neceſſity of confeſſing, That the author himſelf muſt give a key to his works, before we can conceive any meaning either in their ſtructure or ends.

BUT, not to inſiſt further on the puerility and vanity of ſuch philoſophical theology, we ſhall diſmiſs the ſubject with one obſervation upon its neceſſary bad influence, in obſtructing our further advancement and improvement in the knowledge of nature itſelf. How can enquiries into the powers and mechaniſm of nature be carried to any degree of perfection, under the direction of a ſyſtem of philoſophy, which ſets out with muffling up our eyes with a codex of unmechanical laws of matter, preſuppoſed as the baſis of mechaniſm, inſtead of leading us to examine whether theſe themſelves may not be the production of mechaniſm? Such are, The indifference in matter to continue itſelf either in reſt or motion: Reaction being equal to action: The reſiſtance in matter according to its quantity, to change of ſtate: Gravitation, attraction general and elective, of a thouſand kinds: Repulſion, elaſticity, and its oppoſite, plaſticity: Preſſure of fluids in all directions: A fluid with no coheſion of parts, moving in diverging lines; its parts poſſeſſed of different degrees of attractability by other bodies, contrary to that law which makes gravitation ſimply as the quantities of matter: A fluid poſſeſſed of alternate fits of attraction and repulſion, *&c. &c.* To ſay no worſe, it is very ſimple in philoſophers to perceive, that the rearing and whole ſtructure of the ſmalleſt fly, more marvellous than any of theſe, is carried on by mechaniſm; and yet not to preſume that all theſe may be the reſult of mechaniſm alſo.

Of Space, Dimenſion, and the Diviſibility of Matter in Infinitum.

I CLASS theſe three together, becauſe the two latter will ſerve to illuſtrate what is to be conſidered of the former. It is not without reaſon, that in the preſent philoſophy, *ſpace* is always conſidered in the firſt place; becauſe without admitting ſpace void of matter, the whole ſyſtem fails to the ground of courſe.

THE neceſſary ſubſerviency that ſuch ſpace is of to this philoſophy, is a proof that it is founded upon principles as occult as theſe of the peripatetics, which are at preſent treated with ſo much deriſion. But, tho' ſome of the occult qualities of theſe ancient philoſophers can now be explained, it is not handſome in the preſent philoſophers to deſpiſe their ignorance, ſeeing they only acted the very ſame part then, theſe do now, of reſolving theſe things into principles and laws which they could not account for.

BUT the preſent philoſophers have really done worſe, for they have actually aſſumed a principle, or rather a new-invented kind of being, called *empty ſpace*, in order to render their occult principles conſequentially neceſſary: For where nothing is between bodies, nothing to be ſure can agitate or move them, but ſome inſenſible properties inſeparable from their ſenſible ones. Now, tho' *Ariſtotle*, and his nu-

numerous followers, ſupply'd their ignorance with terms of art, which ſtood for principles; yet they never aſſumed any previous maxim, which, while received, prevented any poſſibility of diſcovering whether their occult qualities were any thing elſe but what they called them.

THIS ſame infinite ſpace is the moſt wonderful thing within the whole range of being; to enumerate its contrary definitions is impoſſible. It is neither God nor his creature; and yet it is inſeparable from the being either of God or of any thing he can create. All matter is ſpace, whatever more it is; for ſpace is an eſſential property of matter, it is in ſpace, and ſpace is in it: Wherever matter is, there ſpace is; and there ſpace would be, tho' matter were not there. The ſame holds juſt as true, with relation to it and ſpirit, or it and God: It is infinite both in its extenſion and in its duration; it is immoveable and indiviſible. If a complete definition of it were put into a lady's pocket-book, I am perſuaded there is not a woman that wears one, but would poſitively gueſs it to be an ænigma for NOTHING; and ſhe would be aſtoniſhed to be told that, in the judgment of the learned, it is the quinteſſence of a moſt learned, moſt metaphyſical, and moſt ſubtle argument, maintained upon the ſubject of ſpace by one of the moſt celebrated divines and philoſophers that the laſt or any age has produced.

THE only poſitive idea applied to ſpace, is *extenſion*; but we can apply no idea to any ſubject, which the ſubject itſelf does not impreſs. Matter forces upon our ſenſes the idea or image of its dimenſion or extenſion. It is philoſophical felony to ſteal an image which nature gives us, and inveſt a ſubject with it that never excited any idea in us, and conſequently has no exiſtence to us: We create *nothing* into a being, by applying ideas to it which we derive from *ſomething*. Space is only one of the ideas excited by matter, and by the power of the mind abſtracted from its ſubject, juſt as we can image a colour to ourſelves, without connecting in our apprehenſion a ſubject with it wherein it exiſts: A little more of the ſame metaphyſics which can prove that nothing is extended, will prove that ſpace is purple. But why ſhould I ſay purple? Space is of all colours, if light is reflected by vacuum and not by matter. It is a very ingenious contrivance in philoſophers, to render *nothing* a ſubject of enquiry and conception, by dreſſing it in a ſuit of cloaths borrowed from *ſomething*.

NOW ſpace, or extenſion, being certainly a neceſſary or eſſentially conſtituent property of matter, the philoſophers affirm to us that matter is diviſible in *in infinitum*, at the ſame time they have determined punctually, that ſpace is abſolutely indiviſible: This ſavours rankly of contradiction. The more modeſt friends of this philoſophy are willing to interpret the doctrine of the infinite diviſibility of matter, not as an aſſertion of the actual poſſibility of dividing any parcel of matter without end, but as a mathematical poſſibility of conceiving its extenſion eternally diviſible into leſſer and leſſer extenſions. So far the conceſſion is juſt; for what God created an unit, the niſus of the whole creation upon it could not bruiſe or ſeparate into two; indiviſibility is one of its eſſential inherent properties. But then do they not ſtill propoſe a palpable contradiction, by maintaining its dimenſion, or the ſpace its ſurface meaſures is diviſible infinitely, while they aſſert at the ſame time, that ſpace is indiviſible.

I LATELY ſaw a very pretty, tho' common and ſimple, experiment exhibited, relative to, and intended to illuſtrate, the common doctrine of ſpace; which this is therefore a proper place to make a natural reflection upon. The experiment ſhewed, that by an image formed in the air, at a certain point of diſtance between the concave ſpeculum and any perſon looking into it, extenſion and form became an object of ſenſe, where there exiſts neither ſolidity nor ſenſible reſiſtance. But that does not prove, that an image can be formed in empty ſpace, or where there is no matter; unleſs we can prove firſt, that there can be no matter where we are not ſenſible of reſiſtance. But on the contrary, I infer from that phænomenon, that theſe ſpaces, which in a looſe and incorrect ſenſe we call empty, are as full of matter as theſe in which the moſt ſolid bodies are: For as our ſenſes can be affected only by matter, they are certain infallible ſtandards ſor determining where matter is ; ſo that we may be as aſſured of a fullneſs of matter where we ſee any thing, tho' we cannot ſeel it, as we would be certain there was matter where we felt it, tho' we could not ſee it, or tho' it were the nature of that matter to be inviſible; as I preſume would be the caſe with all ſolid atoms, tho' each were as big as a mill-ſtone: For it is owing to the interſtices in bodies that they become viſible.—All kinds of reflected images conſpire, I apprehend, to prove, that as it is their property by means of light to affect our ſenſe of ſeeing, ſo wherever an object can be formed to impreſs that ſenſe, there muſt be as great a fullneſs of matter as in the original object, from whence the image was trajected to theſe ſpaces where it is again renewed.

THO' the infinite diviſibility of any given extenſion may be eaſily perceived to be a metaphyſical or mathematical ſophiſm, as I muſt take the liberty to call the whole doctrine of infinites, eſpecially as pretended to be canvaſſed by mighty finite capacities; and tho' it is not eaſy to adduce a preciſe refutation of ſuch unconceivable refinements, yet the Newtonian philoſophy, by the relation it eſtabliſhes between power and diſtance, in the doctrine of gravitation, has furniſhed us with the means of a direct diſproof of this. For if the power of gravitation between bodies be as the ſquares of their diſtances;

and if at any given diſtance, (no matter whether we call it a yard or 100 thouſand miles) the power of their tendency towards each other is equal to any given number; then at half that diſtance, the power will be four times as much, and ſo on. Hence it muſt follow, that if that diſtance is diviſible into infinite parts, that power of attraction between them will increaſe infinitely beyond all calculation: But this is groſsly falſe in fact; for we know when bodies come into actual contact, by means of this ſuppoſed power, their reſiſtance to ſeparation again, or tendency to unite, is very limited, and eaſily overcome by an exceſſively finite power. Therefore as at contact, which is the end of diſtance, the power of attraction is finite, of conſequence the ſpaces they traverſe before they meet cannot be infinitely diviſible. And no demonſtration, no not a mathematical one, can be true, which implies a flat contradiction.

Of the Properties of Matter.

AS Natural Philoſophy is principally concerned with matter and its various conditions and powers, it is neceſſary, in order to attain a diſtinct idea of the ſubject, to claſs properly the properties or qualities aſſigned to matter; which fall naturally into three diviſions. Firſt, Theſe properties which are eſſential, and without any of which we can have no idea of it: Theſe alſo are three; 1*ſt*, Solidity perfect and impenetrable, and conſequently indiviſible: One atom may be divided from another, but no atom can be divided from itſelf, becauſe (however mathematicians may quibble about the diviſibility of its extenſion) its ſubſtance does not exiſt by coheſion of parts, or application of one ſubſtance to another, but exiſts in an original continuity of ſubſtance, which is undiſſolveable and unchangeable but by annihilation. In ſhort, an unit of nature is not compoſed of an infinite number of mathematical points, cohering by gravitation, attraction, or any power a name can be invented for.—Why? becauſe a mathematical point is as much nothing as an infinite ſpace is, and therefore the moſt infinite number of them will never make one atom of matter. 2*d*, Whatever is material, muſt have ſize or extenſion, and yet that dimenſion of the largeſt ultimate particle of matter, is in all probability incomparably ſmaller than any mathematical point that the philoſophers can either form any diſtinct idea of, or than they can have any real occaſion ſubſervient to human reſearches into nature to ſuppoſe. 3*d*, Whatever is material, muſt have figure or ſhape: If that were not the property of every the ſmalleſt unit of matter, any collection of them could not acquire that property by combination or coheſion. Theſe three are ſo eſſential to matter, that they may with ſtrict propriety be called the characters of materiality, being each of them inſeparable from any poſſible conception human creatures can at-

attain of the ultimate parts of the material univerſe.

Besides theſe characteriſtics of materiality, there are two other kinds of properties aſſigned to matter, which belong not to its eſſence, but to its motions or the conditions natural to it; one kind of theſe properties may be called,—Secondly, *Abſolute*, becauſe they are conſidered as belonging to every part of matter ſeparately, without any relation to, or connexion with, other parts of matter: Theſe are three alſo, and are aſſumed as axioms in the preſent philoſophy, called the laws of motion. 1*ſt*, Matter is indifferent to continuance in reſt or motion, or rather it has a tendency by which it continues itſelf in which-ever of theſe ſtates it is once put into: This is called the *vis inertiæ* of matter. 2*d*, Every alteration in the ſtate of any body from motion to reſt, from reſt to motion, or from one degree of motion to another, is in proportion to the quantity, and in the direction, of the power applied to ſtop or move it. 3*d*, When matter is put into motion, it communicates juſt as much reſiſtance towards ſtopping or weakening the motion of the body employed to move it, as it receives motion from it: And reverſely, when moving matter is ſtopped or retarded, it communicates juſt as much power towards moving the body which ſtops or retards it, as it loſes in its own motion. To make theſe three laws fully underſtood, and liable to no miſtake, it will be neceſſary to give a definition of what is meant by the term *quantity of motion*, which the leſs ſkilled in ſuch terms may be apt to miſtake for the velocity of motion: And the application of this definition may, without impropriety, be called a 4th law. The quantity of reſt or motion in any body, is in proportion to the quantity of matter in the body; and the reſiſtance it gives to the powers applied to move or ſtop it, is in the ſame proportion. Thus, a body of five pounds weight has five times the quantity of motion that a body of one pound weight, moving with the ſame velocity, has; and by the like proportions are all the circumſtances of motion, reſt, and reſiſtance to be eſtimated.

Thirdly, THE third claſs of material properties ought to be diſtinguiſhed by the name of *relative* ones, becauſe they are ſuppoſed to depend upon ſome mutual influence which the different parts of matter have upon each other. Theſe are gravitation, attraction, repulſion, and if there be any others which we have yet no names for. Attraction, whether it be a diſtinct principle from gravitation, or only a modification of that general principle, may be diſtinguiſhed into *general*, which is the common principle of all coheſion; and *elective*, ſuch as the affection between the loadſtone and iron, oil and oil, water and water, in oppoſition to oil and water, &c. It may alſo be diſtinguiſhed into *permanent*, ſuch as the power of the loadſtone; and *occaſional*, ſuch as electricity, which only actѕ ſenſibly when mechanically excited. ——Repulſion is ſubject to the ſame diviſions.

Of the VIS INERTIÆ.

Matter is indifferent to continue in Motion or in Reſt. A Body in Reſt will reſt for ever, unleſs diſturbed by ſome Impulſe; and if in Motion, will move for ever, unleſs reſiſted or ſtopped.

UPON this propoſition I offer the following thoughts. Reſt and motion are the two greateſt oppoſites in nature. As oppoſite they are as good and evil in morals; more oppoſite than light and darkneſs, becauſe all the darkneſs we know is only comparative and not abſolute; nay, as oppoſite as matter and nothing. The mind cannot be ſtruck with a more palpable contradiction by affirming, that a body is equally diſpoſed to blackneſs and whiteneſs, or hardneſs and ſoftneſs at the ſame time, than is felt upon ſaying a body is equally diſpoſed to reſt or motion. Motion and reſt are not only two oppoſites, as there are many, but they are the fundamental ones upon which all the oppoſitions in nature are founded.

MOTION is a poſitive, which implies action, change of place, power or force whereever it acts. Reſt is a mere negative, in which ſtate body is diveſted of every one of theſe; it exerts no natural power, it weighs, acts, or preſſes neither backward nor forward, up nor down: It produces no effect, and therefore is in the exerciſe of no power. A body which reſts mechanically, being ballanced in its place by oppoſite powers (however ſubtile and inſenſible) preſſing it equally, will, and muſt exert reſiſtance according to the degres of motion another power forces it into; but that which reſts by no power acting upon it, can have no power in itſelf; for all the definition we can give of natural power is, That it is matter either actually moving, or exerting a niſus to motion, as a ſuſpended weight does. But there cannot be conceived any power to reſide, where there is no tendency to action. The ſame body cannot be indifferent to the exerting of actual power, and to the exerting of none, at the ſame time.

AGAIN, it is impoſſible that reſt and motion can be equally indifferent to matter; for if matter was created, the Creator might be ſuppoſed to ſay, let it be, without adding any act of volition, determining in which of theſe ſtates it ſhould commence being. Now in this caſe, it could not come forth both moving and reſting. One only of theſe conditions it could poſſibly aſſume, and muſt have remained in for ever, unleſs ſome further divine energy had given it a new determination. Now, which ever of the two conditions the common ſenſe of mankind will admit matter would take exiſtence in, that muſt be called its natural ſtate; and every alteration of that ſtate, muſt be the effect of ſome power ſuperinduced upon it, which muſt ceaſe when the cauſe ceaſes.

AGAIN, it is allowed matter may exiſt in reſt, but matter in reſt is not life. All life in nature, whether mineral, animal, or vegetable, and whatever characteriſes matter to our ſenſes, depends upon motion, activity, and power in matter: Therefore motion ſeems to be not a natural condition of matter, but ſuperadded, and conſtantly ſupported to conſtitute life, variety, and mutability. If this is not ſo, then upon the principles of the preſent philoſophy the doctrine of the *Epicurean* philoſophy, for ought we know, may be true; for if motion is as indifferent to matter as reſt, we know not but the atoms of matter either moved eternally, or moved ſince ever they exiſted; and all that is ſuppoſed to ariſe out of the fortuitous concourſe of atoms may be true, if their firſt principle, that ſelf-motion is as natural to matter as reſt, be admitted: For whatever is equally indifferent to matter is equally natural to it, and if motion is natural to matter, all the conſequences of it may accidentally become ſo too.

FURTHER, it is evident that all known material motion proceeds upon, and is regulated by mechanical laws, both in its direction and impetus; and, I apprehend, motion, uniformly conducted by the laws of mechaniſm, ſeems naturally to imply a conſtant mechanical cauſe. If this mechanical ſyſtem is traceable in moſt caſes, and in by far the moſt ſubtile and elaborate works of nature, ſuch as plants and animals, why may not the ſame heavens which influence, rule, and move every thing upon the earth, rule the motions of the earth itſelf, and impreſs all matter with theſe general tendencies; which being unalterable, are the baſis of all human mechanics. I think it is doing honour to mechanics (that truly valuable and curious branch of natural philoſophy) to ſuppoſe, that the courſe of nature is framed and conducted upon its principles. Neither I hope is it offering any diſhonour to the Author of nature, to preſume He is ſo great a mechanic, as to be able to conſtruct this vaſt engine of nature, this immenſe theatre of life, beauty, and variety, ſo perfectly and unerringly, that it ſhall execute all his intentions without the neceſſity of the workman's hand always at it in order to keep it going.

ADD to all theſe conſiderations, that the quantity and conditions of inconceivably the largeſt proportion of matter in the univerſe, ſeems to be ſuch as implies its mechaniſm and powers every where. Every naturaliſt knows with what prodigious force the air acts upon any place where it is excluded: There is a perfect torricellian excluſion of elaſtic air, it will be allowed, in the ſpace occupied by a cannon ball, or any other denſe body: It is impoſſible then that it can be conſtantly changing its place with any, even the higheſt, degree of velocity, but it muſt be as conſtantly preſſed upon behind, in the direction of its motion, with all the power and force that air preſſes into a vacuum. This muſt certainly have great influence, tho' totally overlooked by our philoſophers, in the propagation of all motions we are converſant in.

Besides, this rare, fine-ſpun body *light*, as the preſent philoſophy repreſents it, furniſhes the moſt obvious and inconteſtible proof of its being the moſt denſe and omnipreſent of all bodies. For, not to carry my reader out of the room, where he may be peruſing this paper, for a proof of it, let him only conſider what his ſenſe teaches him, and what the preſent philoſophy admits, tho' it ſeems never to have regarded the concluſion which muſt follow upon it. There is not one viſible point in the room which does not emit perfect continuous lines or rays of light to the eye in all directions: If all the room were eye but one viſible point, all the eye would ſee it in every point. It is very true, the philoſophers may call theſe diverging rays, becauſe the point may be conſidered as a centre, and the room as a circumference; but when we conſider that there is not a point in the circumference where this point as a centre is not viſible, one would think that this very conſideration would go well nigh proving a fullneſs of the matter, as well as of the form of light in the room. But when the conditions of light, with regard to one ſingle point of the room, proves ſo much, what ſhall we ſay when we conſider the room as a continuation of an inconceivable number of ſuch viſible points ? Every one of which is viſible in every other point, or every one of which implys in its conditions the proofs of a plenum: Rays diverging from every point, and rays converging to every point without exception. Can human underſtanding or conception form an idea of ſuch a thing, without neceſſarily falling under the conviction of a plenum, from theſe two oppoſite circumſtances, of all viſible objects within that compaſs of each other, to the extent of all that the eye can in any place comprehend of heaven and earth. This is the moſt concluſive experimental philoſophy, without the aſſiſtance of one inſtrument, as to this matter. But how philoſophers came to know what would be the circumſtances of motion where there was no matter, ſave the body ſuppoſed to be moved, is beyond the compaſs of my reflection ; and it is no leſs unconceivable how motion can be carried on in ſuch a medium, without the medium being concerned in it.

Of the SECOND LAW OF MOTION.

Every Alteration in the State of Body, from Reſt to Motion, or from Motion to Reſt, is in Proportion to the Quantity, and in the Direction, of the Power apply'd to move or ſtop it.

WE have, we can have, no other idea of power, but that it is matter in motion or exerting a niſus to motion. All power being reſolvable into a tendency to motion, it is impoſſible to connect the idea of power to matter at reſt, unleſs that reſt be the effect of power fixing it in its place, which may properly be termed *mechanical* reſt. This reſt being the effect of power, will exert a reniſus or reſiſtance to motion, when it is acted upon or preſſed to change its ſtate. But matter in an uninformed ſtate, unconnected with all ſympathy or mechaniſm, unacting and unacted upon, can have no power in itſelf, can exert none, becauſe power conſiſts in motion or a niſus to it. The only idea we can have of a niſus to reſt is, a tendency to motion, ballanced by reſiſtance; becauſe tendency to action is neceſſarily implied in the term niſus: Therefore matter reſting unmechanically, that is, without any cauſe, can have no niſus in itſelf, elſe it would begin motion thereby, and continue it while that niſus remained in it. An unmechanical niſus in matter to reſt is, in other words, an active power exerted by it to do nothing, or to keep itſelf from doing ſomething; and to ſuppoſe that matter in reſt exerts any virtue or power to preſerve itſelf in that ſtate, is ſuppoſing, that without that virtue it would fall into motion.

THE ſtates then of motion or reſt being the reſult of abſolute paſſiveneſs in matter to either, and the effect of no poſitive niſus towards them; therefore in an unmechanical ſtate, matter can exert no reſiſtance to change that ſtate, and of conſequence, an atom of matter would have as much power in moving matter the ſize of a planet, as the latter would have in moving the former, as neither of them can poſſibly have either reſiſtance to motion, or tendency to it, longer than they are moved by ſome power acting upon them.

As action, or energy towards action, is inſeparable from the idea of a niſus to any ſtate; and as a niſus to paſſiveneſs is a contradiction in terms, it is rational to conclude, that the principles and properties of power or motion, cannot be looked for in matter conſidered abſtractly, but in the organiſation or ſyſtematic ſtructure of it. Therefore, tho' it muſt be allowed that the changes of ſtate in matter, are proportioned to the powers which produce them, yet it is impoſſible to conceive that the power ſhall continue in the body acted upon, after the exteriour power ceaſes to act upon it; or that bodies have an innate faculty of changing virtues or niſuſſes with each other every time there is a colliſion between them. Shall we be told, and will any rational perſon believe upon the word of a philoſopher, that a body at reſt has a niſus to reſt, which yet does not prevent its moving whenever it is ſtruck; but when it is ſtruck, the niſus to motion leaves the body ſtriking, and paſſes into the body ſtruck, while the niſus to reſt departs from the body ſtruck, and enters into the body which ſtruck it. Can this incomprehenſible chimera gain credit with rational enquirers into nature.

It is not only impoſſible to ſeparate the notion of power from that of material action, which is *motion*, but it is alſo impoſſible to ſeparate the idea of power from that of *reſiſtance*. We can form no conception of power nor proportion of quantity in it, but comparatively, by ſome reſiſtance it is conceived to overcome, or be matched with. There is reſiſtance overcome in the very action of power, tho' its efforts are directed againſt no ſenſible object. In brandiſhing the arm or a weapon, or in the working of any engine, tho' not applied to produce any effect, there is a conſtant reſiſtance overcome of the weight, &c. of the body ſo moving; and abſtract theſe from the motion of the body, we will find that all our ideas of motion will vaniſh, and alſo all conception of any effect, that can poſſibly be produced; for if theſe properties in any moving power, which imply a re-niſus to its motion, were abſtracted, we can have no notion of the motions producing any effect; becauſe the momentum of motion or power, lies in that very property of the moving body, which gives it at firſt a proper, felt reſiſtance to any given ſenſible quantity of power applied to move it.

Of the Third Axiom *or* Law of Motion.

When Matter is put into Motion, it communicates juſt as much Reſiſtance towards ſtopping or weakening the Motion of the Body employed to move it, as it receives Motion from it.

THE preſent philoſophy would perhaps think this law more properly expreſſed in the following terms: When one body acts upon another, the action of that body upon the other is equalled by the contrary re-action of that other body upon the firſt. The philoſophical wording of the moſt common phenomenon ſhould be carefully examined and attended to, for ſometimes it means ſomething very different from the idea that the phenomenon itſelf ſuggeſts to our ſenſes. It requires a good deal of philoſophical addreſs in the uſe of words, to explain, for example, the appearance of reſiſtance which one body meets with when it moves or ſtrikes againſt another, into terms which are intended to convey a philoſophical idea diſtinct from proper reſiſtance; tho' all the circumſtances which attend ſuch a phenomenon are individually and undiſtinguiſhably the ſame as are produced by proper reſiſtance. If one puſhes his finger forcibly againſt a ſtone or any hard body ſuſpended, a cautious circumſpect writer will not ſay the finger is hurt by the reſiſtance it met with; but he will chuſe to expreſs it rather thus, the finger being a ſenſible ſoft body, the parts which come firſt into contact with the ſtone have their motion retarded, while the other parts will be advancing forward with their original violence. But certainly this definition of the matter, however learned, muſt ſeem very ſimple when one aſks this plain queſtion: Does not this very ſame thing in all its circumſtances happen, when the finger is puſhed with violence where it meets with proper reſiſtance? It is a maxim in ſound philoſophy, that like cauſes produce, under the ſame circumſtances, like effects; and conſequently, ſimilar effects imply like cauſes. It is impoſſible for me to comprehend, why the preſent philoſophy, in its very poſtulata or firſt axioms, ſhould fly in the face of this rule of reaſoning, without holding to which, reaſon has abſolutely no ſtandard for inveſtigating any operation of nature, which is not the palpable object of ſenſe. It ſeems as if at firſt ſtarting, it were propoſed not to enquire if there was any inſenſible mechaniſm in nature, and how far it could be traced, but to exert the utmoſt ſophiſtry in order to diſprove and reject it. The philoſophy ſeems to have aſſumed a vacuum, empty ſpace, as its idol and firſt neceſſary principle, and we muſt not truſt our ſenſes, or any argument drawn from ſenſible powers which threatens to interfere with it.

If this was not the caſe, what other need could there poſſibly be for defining all the ſigns of proper reſiſtance by any other than its own proper name, *reſiſtance?* There are all the ſigns of poſitive reſiſtance to be perceived in matter, whether moving or reſting,

ing, in this natural ſtate in which it is exhibited to our ſenſes and examination. Reſiſtance implies power (as I ſhall ſhew immediately) which is nothing elſe but either a niſus to motion, or an effort to reſtrain from motion. To aſſert any proper powers or virtues in matter, would be to maintain the doctrine of occult qualities, which are exploded; therefore it ſeems to be thought neceſſary to diſguiſe theſe manifeſt appearances of power in matter under ambiguous terms; where a fact, a poſitive, is defined under phraſes which convey only a negative to the mind, or which convey no idea at all.

VIS INERTIÆ is the general term the philoſophers have agreed upon, to expreſs the doctrine contained in theſe aſſumed primary axioms of mathematical philoſophy. They themſelves are diſcontented with the word *vis*, as too explicitly expreſſing what they would not be underſtood to ſay; and therefore they joined *inertiæ* to it, as phyſicians compound acids and alkalis; in order to deſtroy the meaning of *vis*, and neutraliſe the expreſſion, ſo that it may be underſtood to mean neither a poſitive nor a negative. But to decide the point as to this third axiom:

I SAID I would undertake to ſhew, that this law was regulated by, and entirely depended upon, proper power; *power* ſo acknowledged by the preſent philoſophers themſelves. They never had it in their power to make the experiments or obſervations, on which they eſtabliſh this axiom, upon any bodies but ſuch as were under the influence of gravitation; and if this axiom can be demonſtrated to depend upon gravitation, whether we conceive it a law or a mechanical power, then it muſt ceaſe to be an axiom, as being only a ſecondary accident or circumſtance depending upon another avowed cauſe.

THAT the niſus of gravitation, mechanical or not, no matter at preſent, is a proper power none will doubt, unleſs they take upon them to diſpute whether there is ſuch a thing in nature as power. Power is, and can be nothing elſe, than a niſus to material action, which is motion. Reſiſtance or re-action muſt be produced wherever matter in motion encounters matter either moving, or having a conſtant tendency to move, in an oppoſite direction; or in any direction which deviates from that in which it is ſtruck or impelled by another power. To paſs here the power of coheſion, by which the parts of bodies are powerfully determined to preſs inwardly upon one another, in what may be called a centrical direction; all bodies have a tendency to gravitate downward or toward the earth, therefore this tendency muſt react or reſiſt, according to its quantity, upon every power applied to move a gravitating body in any other direction.

THE philoſophers ſay, that matter reacts according to its quantity of matter: But, what is ſurpriſing, they ſeem never to have conſidered that we have no mean of eſtimating the quantity of fixed matter contained in any bodies, but by that quantity of gravitation, or unvariable power, tending always to move in a prone direction, or downward: Hence we muſt neceſſarily infer, that the law of reaction is not according to the quantity of matter, in particular detached parcels thereof, but according to the power of gravity acting between them and the earth; for let us ſuppoſe, that the gravity between the earth and any body were one half leſs than it is, it would follow, that that body would have but one half the reaction that it now poſſeſſes; and of courſe, if that gravitation were altogether ſubſtracted, or ſuſpended, then it would exert no reaction at all, and the axiom becomes totally falſe.

LET us take the caſe in a reverſe light; it is ſuppoſed, that the power of gravitation is 23 times greater upon the ſurface of the ſun than it is upon the ſurface of the earth; hence a body which weighs one ſtone here, would there weigh 24 ſtone, and conſequently would re-act 23 times more than it does here, without any additional quantity of fixed matter in it: Therefore this reaction aſſumed as an abſolute law inherent in matter, diſtinct from, and independent of its other characters and properties, is only a circumſtance which depends upon the relative law of gravitation. The matter ſcarcely needs any further illuſtration, but as a deciſive one occurs I ſhall ſtate it. Suppoſe a pound of iron is attracted by a loadſtone, with a power equal to the weight of three pounds more, it would follow in fact, that that pound of iron, under this ſtate of attraction, would reſiſt motion, or react upon any body ſtriking againſt it, as if it contained four times the quantity of matter it really does contain.

THEREFORE, upon the whole it follows, that two fundamental doctrines of the preſent philoſophy muſt be falſe. 1*ſt*, The doctrine of reaction can be no axiom, nor primary law, but only a neceſſary conſequence of gravitation. 2*dly*, The law of gravitation, as ſtated by the philoſophers, is no deciſive proof of the quantity of fixed matter in bodies; ſince the influence of the loadſtone will encreaſe the weight of iron, or its reſiſtance to any given impulſe applied to move it, without encreaſing its quantity of matter.

Of the Centripetal and Centrifugal Forces; Or, of the joint Influence of Gravitation and Projection, in producing the Revolutions of the Planets.

Firſt, *From the defined Nature of theſe two Powers, it is impoſſible they can produce ſuch an Effect.*

IN another age, if not in this, it will be looked upon as a ſubject of univerſal wonder, if not deemed incredible, that one of the moſt profound mathematicians in the world ſhould aſſume two powers for circulating the planets, and eſteem them ſo certain as to undertake to eſtimate the very quantities of matter in the celeſtial orbs, by the moſt intricate and elaborate calculations, made upon the ſuppoſed relations of theſe powers to one another, and the proportions in which they muſt act in producing and maintaining the circuits of the moving ſtars; while it is demonſtrable to common ſenſe, from the admitted nature of theſe two powers, that it is abſolutely impoſſible that they can ſupport one ſingle rotation of any orb, in any of the areas they are ſaid to deſcribe.

GRAVITATION is allowed by all to be a conſtant power inherent, or acting in bodies, which cannot be ſuſpended nor altered, but by change of diſtance between the bodies mutually ſo affecting each other. It cannot be ſuſpended, for tho' its tendency may be reſiſted, yet all its niſus to that tendency remains invariably exerting itſelf, or preſſing towards it. It is therefore a proper, undeſtroyable power, uninteruptedly acting in or upon bodies.

THE characters given to *projection*, as a power, are expreſsly the reverſe in every reſpect. When in motion, it is ſaid to have no proper reſiſtance to change of ſtate, whereas gravitation, even when bodies are at reſt, reacts and exerts a niſus to move. When any proportion of the quantity of projectile motion is deſtroyed, either by direct oppoſition, or by oblique alteration of the direction of its progreſs, projection acts as no niſus to recover the original quantity of motion it was projected with; conſequently, as long as any power, ſuch as gravitation, is conſtantly concurring to bend the direction of projection, it muſt be conſtantly eſteemed as ſo much continued reſiſtance to the power of projection; and projection conſtantly ſuſtaining, by that degree of reſiſtance, a diminution of its momentum, or quantity of motion, which by the acknowledged properties of that power it has no niſus ever to recover, the ſmalleſt continued reſiſtance which is able either to retard its motion, or vary continually its direction, will at laſt exhauſt its power, tho' originally never ſo great, and leave the body at laſt ſolely to the influence of that power which has acted as reſiſtance to its projectile motion. This is the caſe with every projectile on the earth, however ſuperiour the projectile force may be in any body at ſetting out, yet it is ſoon weakened by the gravitating power, and is retarded till it comes to reſt in the direction of a parabolic curve.

THE great Sir *Iſaac Newton* has admitted ſomewhere, that theſe two powers of projection and gravitation, may be ſuppoſed to be ſo regulated that their direction may deſcribe ſuch a curve figure, that any line drawn from the centre to the area of motion, will every where fall upon it at the ſame angle. By this figure, I ſuppoſe, he muſt mean a ſpiral one, for I know of no curve to which that property will apply, ſave that of a perfect circle, and a ſpiral curve. But he has no where, that I know, reflected upon this circumſtance of the two powers of gravitation and projection; that the one retains its whole niſus to motion, whether it be retarded or ſtop'd, while the other altogether loſes as much power as it meets with oppoſition; neither, in his ballancing theſe powers, does he ſeem to have reflected upon one of the moſt obvious truths in geometry, that every alteration in the direction of the motion of a projectile, is equivalent to a proportionable deſtruction of the momentum of of its motion, which cannot be repaired without ſuppoſing that projection is not a firſt impulſe, but a continued action of the primary moving cauſe, not ballancing gravitation by the laws of projectile motion, but by his own conſtant agency.

A SELF-CONTRADICTION being implied in ſuppoſing bodies can act where they are not; and philoſophy having certainly pronounced, that there can be no ſelf-motion where there is not an immaterial principle inherent in bodies; becauſe of theſe two maxims, the doctrine of gravitation and attraction laboured under all the ignominy of the reprobated hypotheſis of occult qualities; until ſome ingenious friends of the preſent philoſophy reſolved that doctrine into the immediate agency of the Deity. If the impoſſibility of ſupporting the original power of projection, while it ſuſtains a conſtant reſiſtance from gravitation perpetually bending and altering its direction, ſhall reduce the preſent philoſophers to explain the perpetuity of projectile motion, tho' labouring againſt a continual reſiſtance, into the conſtant agency of a firſt cauſe alſo, then the whole philoſophy, name and thing, falls to the ground at once. For every one muſt acknowledge, that without any reſpect to theſe two nominal powers, it is more eaſy for the Deity to move the planets round in any kind of curve he pleaſes, than it is for a man to make a ball in his hand deſcribe a circular motion.

Philosophers have illuſtrated to us the joint effect of centripetal and centrifugal motion in making bodies move in a circle, by the ſimple experiment of caſting round a weight ſuſpended by a ſtring in one's hand: But this illuſtration, tho' plauſible, contains a very palpable deception. For the power of the ſtring reſtraining the body from flying off in a tangent, bears no analogy to a power actually drawing the moving body towards its centre of motion. The ſtring reſiſts its flying off, but it has not the leaſt tendency to draw it nearer: And truly, if ever the philoſophers diſcover the genuine cauſe of the revolutions of the planets; I mean that power which regulates their direction, I will venture to determine *a priori*, that it muſt be ſome power which ſimply reſiſts their receding into eccentric motions; for it cannot in the nature of things, be one which is either drawing or puſhing them uniformly into their centre of motion.

Second, *Of the Impoſſibility there is that the Powers of Gravitation and Projection, can move the Planets in theſe Orbits, in which aſtronomical Obſervation has diſcovered they move.*

LET us now ſuppoſe, what the preſent philoſophy (tho' eſſentially neceſſary to that ſyſtem) does not aſſume, but on the contrary denies in its very firſt principles; That, namely, the powers of gravitation and projection, are endowed with the ſame poſitive properties of ſtill retaining their original niſus to their reſpective motions, however they may be retarded by counteracting each others directions; by which means the rotatory motions of the aerial orbs are preſerved: Yet allowing this, it is impoſſible that theſe two powers, acting by immutable laws, can move any orb in any other area ſave that of a circle; whereas all the planets are allowed by the philoſophers themſelves to deſcribe ellipſis.

THESE powers moving an orb in the figure of an elipſis, muſt no leſs than four times vary the proportions of their reſpective impulſes, during the period of every complete revolution. The power of gravitation is uniformly gaining upon the power of projection, in the motion of a planet, from the higher apſis of the ellipſis in which it moves, until it comes to the lower. I aſk not how the projectile force recovers itſelf at all again (ſeeing it is none of the properties of that power to recover the motion it has loſt, tho' the counteraction to it ſhould ceaſe) but ſuppoſing projection in that reſpect, of the ſame nature with gravitation; I aſk, by what law between theſe two moving cauſes, does gravitation remit the ſtrength it has gained in bringing the orb from the higher apſis to the lower, and at that point allow projection to recover again the momentum it has loſt, in order to carry the orb back again from the lower to the higher apſis of the ellipſis? In like manner, ſeeing projection has been gaining upon gravitation all the way to that point, how comes it all at once to loſe its ſuperiour momentum there, and how comes gravitation immediately to begin to preponderate, in order to bring the orb back to the lower apſis again?

I DO not know a more groſs miſapplication of geometry, in the mathematical philoſophy, than the reaſoning they ſatisfy themſelves, and impoſe upon others with, in that point, by referring the properties of a figure to powers of motion, which have not power to deſcribe the figure. I grant it, it is true, that at theſe points where a radius drawn from the focus falls at right angles upon the tangent at the point of contact, there the figure begins to turn from the lower apſis towards the higher, or *vice verſa*; but is that any reaſon why the powers of projection and gravitation ſhould be ſufficient to cauſe any orb deſcribe ſuch a figure? But ſay they, the planets do deſcribe theſe figures, and we know of no other power concerned in their motions, beſides theſe powers of gravitation and projection, which we ſenſibly know all bodies are under the influence of. I anſwer, if the planets do deſcribe areas which the laws aſcribed to gravitation and projection are not ſufficient to execute, it is a proof, either that theſe powers are not concerned in revolving the planets, or that they have a ſecret intelligence between themſelves in exchanging their momentums occaſionally, which contradicts the known laws aſcribed to theſe powers.

It cannot be argued, that the encreaſed velocity which brings a planet to the lower, contributes to carry it out again to the higher apſis, for that encreaſed velocity was not the effect of projection but gravitation; therefore the orb can never get outward again, unleſs at that point gravitation all at once weakens its pull of the planet inward.

This leads me to examine that very pretty and ingenious (I muſt call it) tho' fallacious experiment, which repreſents the motions of the planets and the alledged powers which maintain them, by a ball ſuſpended by a ſtring, brought to the verge of a circle formed round its point of reſt, and there ſtruck in the direction of a tangent, with a force either equal or ſuperior to the radius of the circle; by which means the ball will deſcribe either nearly a circle, or an ellipſis. It is allowed that the ball brought to the verge of ſuch a circle round its loweſt point of ſuſpenſion, and left to itſelf, will tend to that point; it is alſo acknowledged, that the ball ſtruck in any direction beſides that of its tendency, will deſcribe nearly a circle in one caſe, and in all others a kind of an ellipſis. If it is ſtruck in the direction of a tangent, with a force ſuperiour to its tendency, it will deſcribe an ellipſis, whoſe conjugates coincide with the verges of the circle it is ſtruck from; if with a force weaker than its tendency, it will deſcribe an ellipſis, whoſe tranſverſe diameters coincide with the verge of the circle; if it is ſtruck in any direction, ſave that of a tangent, with a force ſuperiour to the radius of the circle, it will deſcribe an ellipſis that cuts the circle four times, the conjugates being within the circle, and the areas of the tranſverſe diameters without it.

AFTER all this, it remains to be demonſtrated, that in the motion of this ball, there is a cauſe concerned which takes no place in the ſuppoſed cauſes of planetary motion; and alſo that the eliptical figures deſcribed by the ball, differ eſſentially from theſe deſcribed by the planets: If this is the caſe, the experiment can neither be any illuſtration, nor any explanation of their motions and the cauſes of them.

IN the firſt place then, the ball in the experiment is ſuſpended by the ſtring, ſo that it is reſtrained from deſcending in the direction of its centripetal force beyond a certain point in ſpace, namely, the loweſt, to which it deſcends by the determinate length of the ſtring; ſo that when the ball is at reſt, and no projectile power acting upon it, there is a re-action to its gravity acting upon it, and preventing its purſuing its own centripetal niſus. This reſtraining power is the cauſe of all the peculiar phenomena of its motions; but the planets are ſuppoſed to have no ſuch reſtraint upon their centripetal tendency, which would of itſelf, without the interpoſition of projection, prevent their tumbling into their centre of attraction in a direct courſe. But verily, as I have already alledged without diſcovering a third power, which both reſiſts their centripetal force, and binds in the projectile one, as a bowl does a ball rolling up and down in it, or as the ſtring does the ball in the caſe under conſideration, theſe two powers will never be demonſtrated ſufficient of themſelves to perform one planetary revolution.

In conſequence of this third reſtraining power of the ſtring, by which the ball hangs, the firſt phenomenon which depends on it is, that whenever the ball is acting at the ſtring's length, and in any direction, except the perpendicular, it cannot attain its loweſt point of ſuſpenſion where its gravity will reſt, ſave by vibrating to it in the direction of a curve, or in the ſegment of a circle. This would not be the caſe with a planet if projection were ſuſpended, it would ruſh to its centre in a direct line at any given point of its courſe, being no where either higher nor lower than the point it would tend to.

AGAIN, it is ſolely owing to the third power in the caſe of the experiment, that all the elipſes it can deſcribe are ſpherical ones; ſuch ellipſis, I mean, as one deſcribed in the inſide of the bottom of a bowl, or ſpherical veſſel, would be, where the tranſverſe diameters are higheſt as well as fartheſt removed from the centre of the figure. This is a circumſtance which never was aſcribed to the areas of the planetary ellipſis, therefore the illuſtration is not adequate to, and ſo cannot be explanatory of, what it is adduced to explain.

LASTLY, from attending to the above peculiarity in the figure of the ellipſis, which the ball deſcribes, we ſee an evident reaſon for the acceleration and retardation of the motion to and from the conjugates; becauſe there is an aſcending and deſcending in this caſe, which cannot be applied to the planetary ellipſis, unleſs along with gravitation we allow them a ſuſpenſion of their gravitation, equivalent to the ſtring or third power in the caſe of the ball; and that they muſt have before they can move in the figures they deſcribe. When that is acknowledged, it will be then time enough to enquire, whether, allowing all friction and reſiſtance of mediums to be removed, both the ball and planets would not gradually decline in their figures to their loweſt point of ſuſpenſion, and ſo come at laſt to reſt.

THERE is however, one pretty, obvious,

and certain like-inference, which ſeems natively to offer itſelf, upon the circumſtances of motion and figures deſcribed by the ball in this experiment; which the mathematicians ought to conſider well and examine: It is this, that no figure can be conceived to be deſcribed by gravitation and projection round the centre of gravity, where that centre of gravity ſhall not always be found in the centre of the figure; whether it is a circle or an ellipſis. This however, is contrary to all aſtronomical obſervation upon the motion of the planets, which has determined their centre of gravity to be always in one of the foci of their elliptical orbits.

Thirdly, *Of the mathematical Proportion required between the Powers of Gravitation and Projection, in order to the circulating of the Planets round their Centre of Gravity.*

THE diſproportion is here ſo glaring and irreconcilable with all the plaineſt rules of geometry, that I am almoſt aſhamed to ſuppoſe, it has eſcaped the obſervation of the moſt profound mathematicians; and if it has not, I am abſolutely at a loſs to account for their ſilence upon it.

As a primary illuſtration and demonſtration of the joint effect of projection and gravitation in circulating the planets, it is always proved, that a body impelled in different directions, by two powers at the ſame time, will deſcribe the diagonal of the parallelogram of theſe two powers: From which ariſes two ſelf-evident corollaries. 1*ſt*, In the ſame proportion that any two powers cauſe the impelled body decline from the direction of their different impulſes, in a like proportion do they deſtroy the effect of each other's powers upon the impelled body: Or, in other words, as the angles are which the diagonal makes with the ſides of the parallelogram, ſo will the length of the diagonal be to the lengths of the two ſides. 2*dly*, In that proportion in which the one power exceeds the other, in a parallel proportion will the direction of the diagonal approach nearer to the direction of the greater power; or, as the lengths of the ſides of the parallelogram are in proportion to one another, ſo will the largeneſs of the angle be, which the diagonal makes with the ſhorter ſide of the parallelogram, and the acuteneſs of the angle which it forms with the longer ſide.

FROM the relation then that the diagonal bears to its parallelogram, it muſt follow, that in order to move a planet or any body in a circle, or nearly in one, it is required that the moving powers be equal or nearly ſo. The proportion of the moving powers to one another, can only be determined upon one and the ſame body or planet, by the velocity of the reſpective motions with which the moving powers do impreſs it. By the velocity of the motions, I ſay, for tho' the quantity of the motion in different bodies muſt be determined by the quantity of matter moving, and the velocities taken together, yet in one and the ſame body, the quantities of its motion muſt be determined ſolely by the velocities of that body's motions.

Now equal powers muſt be neceſſary to move any body in a circle. Equal powers can only be determined by the equal quantities of motion they produce; but in the caſe of the powers of gravitation and projection, which are ſuppoſed to conduct the earth's revolution, the proportion between them, as aſcertained by the ableſt mathematicians and moſt ſtrenuous ſupporters of the preſent philoſophical ſyſtem, is ſo far from being equal, that the immenſe diſparity between them can ſcarcely be reduced to calculation.

If the ſun and the earth were as near each other as the earth and the moon are, and were left to the power of their mutual attraction, they would move towards each other with the ſame velocity, as it is ſuppoſed the earth and the moon would do, which is, I think, about 16 feet in a minute. It is true, their quantity of motion would be vaſtly greater, becauſe their quantity of matter is ſo, but ſtill by the laws of gravitation, their gravitating velocities would be parallel to theſe of the earth and moon; excepting ſo far as the proportion of matter in the earth to that in the ſun, differs from that of the moon to the earth. If then the earth at that diſtance from the ſun, which the moon is from the earth, would gravitate towards him with the velocity of 16 feet in a minute; and if the decreaſe of gravitation be inverſely as the ſquares of the diſtances, that is, at double the diſtance, four times leſs, and at thrice the diſtance, nine times leſs; then the earth being immenſely more diſtant from the ſun than the moon is from the earth, the velocity with which the earth at her preſent diſtance from the ſun would move towards him, if left to the power of attraction, muſt be immenſely leſs than that of 16 feet in a minute. But what is the momentum of 16 feet in a minute, or even a thouſand times that, to the momentum of projection, which is ſaid to impel the earth at nearly the rate of a thouſand miles in a minute?

IT is evident in mathematics, that the diagonal of a ſquare makes an equal angle with both the ſides; and this is uſed as a demonſtration, that it requires equal powers, or forces which act with equal momenta, to incline any planet's motion into the direction of a circle. But if we find two powers condeſcended upon for effecting this, whoſe momenta bear not the proportion to each other of one to 10,000; theſe powers cannot be repreſented by the two ſides of a ſquare, but by the ſides of a parallelogram, the length of whoſe ſhorter ſide bears not to the longer, the proportion of one to 10,000. It is further evident, from the ſecond corollary above-mentioned, how nearly the diagonal of ſuch a figure will approach to the direction of the longer ſide; and if ſuch a diagonal is ſuppoſed bent into a curve by the power repreſented by the ſhorter ſide, it is evident that curve would form no part or ſegment of a circle or ellipſis, but of an eccentric curve, which would hurry the orb farther and farther from, and ſo faſt diminiſh and totally exhauſt, the weak influence which the ſmaller power had upon it. In ſhort, if the power of gravitation impels or draws the earth towards its centre of gravity, with the momentum of an inch, a foot, ſixteen feet, or 1600 feet in a minute (it does not ſignify which) while the power of projection impreſſes it with the momentum of almoſt 1000 miles in the ſame time, it is impoſſible for mathematics to demonſtrate, that an orb hurried off by ſuch a projection, where there is ſuch an inconceivably ſmall and diſproportionate a reſiſtance, can ever be recalled again from its eccentric motion; eſpecially as the power of gravitation, inconſiderable as it is, muſt be growing weaker every minute, nay every ſecond of its motion. Nor can the mathematical properties of an ellipſis, or of any figure, ever prove that gravitation, which it is momentarily waſting and ſpinning out to a cobweb thread, will at any point recover a ſuperiority to the projectile momentum, and grow at laſt a cable, maſſy and powerful enough, to bring home the wandering ſtar again.

SOME may apprehend the force of the above objection ſufficiently obviated and removed, by the reſolution of the powers of gravitation and projection into the mathematical relation of the proportion which an arc bears to its verſed ſine, and by telling us theſe powers muſt be equal, if it is found that gravitation would move a planet left to its power, the length of the verſed ſine towards its centre of gravity, in the very ſame time that projection does carry it thro' that arc which correſponds with the verſed ſine.

BUT I have ſhewn already, in relation to elliptical figures, how fallacious it is to reaſon from the properties and relations of figures, to the ſuppoſed powers of motion, and it is no leſs evident here: For the accelerated motion of a gravitating body, thro' any given ſpace, cannot be attributed to the power of gravity ſolely: The whole acceleration, it muſt be allowed by all, is maintained by the *vis inertiæ*, or tendency in matter, to preſerve every quantity of motion it momentarily derives from gravity. If the moon were allowed to begin at the diſtance of 300 feet to fall towards the earth, ſhe would not deſcend by the force of gravity ſo faſt as a ſtone does from the ſame height: Therefore the immenſe acceleration ſhe would acquire in deſcending from her preſent diſtance, muſt be referred not to the power of gravity, but to the ſecond axiom of the preſent philoſophy; and it is a groſs fallacy, to engroſs that law to eke out the momentum of gravity, in order to ballance it with the projection of the planets. So that in fact, if the real quantity of power of motion, excited by gravity itſelf, were to be analized by the doctrine of fluxions, which certainly the mathematicians will not refuſe to do, it would be found a mere evaneſcent quantity, which imagination itſelf could not poſſibly bring into any conceivable commenſuration, with ſuch a poſitive and immenſe power, as that of projection is allowed to be in the caſe of the planetary motions.

BUT to give the argument for gravitation as much advantage as poſſible, I have in my reaſoning above, conſidered gravitation as a poſitive power, in which caſe, I ſay over again, that the powers muſt be equal which incline any body into a motion, whoſe direction lies equally between the directions of the two powers.

FOR further proof of this, if it is neceſſary, let us examine gravitation by comparing it with the only power, tho' merely a reſiſting one, it can be exemplify'd by, namely, the ſtring by which a ball hangs while by projection it moves in a circle. No line can ſuſtain the momentum of a body moving round, but what is at leaſt able to ſuſtain the weight of that body at reſt. Therefore, the poſitive momentum of gravitation muſt be as great as that of projection, which it cannot be, unleſs their velocities are equal when their powers act ſeparately. It would be a mere evaſion to alledge, that the gravity or real weight of the earth at our diſtance from the ſun, is as ſmall, as it is ſuppoſed its motion would be ſlow at firſt, if left to its gravitating power; ſo that a ſmall power may keep it in its projectile courſe. For, 1*ſt*, No power but a reſiſting one can have this effect of keeping any projectile in an orbit. The diſpute here with the preſent philoſophers, is not by what agent they ſuppoſe gravitation to be performed? It ſignifies nothing tho' they ſhould ſay, they don't determine whether it is ſpiritual or material; whether it acts by drawing or puſhing. The queſtion is, can any power which acts in a direction towards a centre, be combined with any other power, ſo as to maintain the motion of any body round that centre, without bringing that body either gradually into the centre by the uninterrupted application of its momentum, or by allowing it gradually to recede from it into irrecoverable eccentric diſtances by its unproportioned weakneſs? The whole ſcience of mathematics cannot demonſtrate that any power, but a reſiſting one, can produce the revolution of bodies in orbits, or that any power which uniformly puſhes inward, can produce it.

2*dly*, I PROVE, that that power of gravitation muſt be equal to the momentum of projection as a moving power, in order to its ballancing the direction of the planets equally between the directions of the two powers; and that according to the doctrine of the preſent philoſophy, the reſiſtance of the earth to the influence of gravity acting upon it, muſt be equal to what perſons upon the earth, judging of weight, would compute the earth to be; nor can it decreaſe in proportion, as it is ſuppoſed the quantity of its gravitating motion decreaſes by diſtance.

By the axioms of this philoſophy it is eſtabliſhed, that the momentum of motion in any body will be according to, what is called, its quantity of matter. Now, if the projection of the earth muſt act with ſo great a momentum, then in order to ballance it, gravitation muſt act with a reſtraining power equal to that niſus of power which would be at leaſt neceſſary to ſuſtain its weight, according to our ideas of weight here upon the earth; for no line which cannot ſuſtain the weight of a body, can ſuſtain the momentum of projection, and give it a circular direction. But a power, whoſe niſus would be ſufficient to ſuſtain the weight of the earth, or give its projection a circular direction, if applied in the direction either of drawing or puſhing it to a centre, would give it the ſame velocity in that direction, as projection would give it in cauſing it to move in an orbit by the help of that reſtraining power.

Of the MOTIONS *of the* SATELLITES.

IT is no wonder, that notwithſtanding the many and ſtrong grounds of probability there are for the motion of the earth, yet the greateſt aſtronomers have not taken upon them to maintain it as a matter of abſolute certainty, contenting themſelves to reaſon upon it as a probable hypotheſis. Among the perplexities which attend that highly probable ſyſtem, I think the doctrine of abſolute motion none of the ſmalleſt. It is certain, that all the phenomena of relative motion are in every reſpect the ſame as if the earth were at abſolute reſt; and it is not eaſy to conceive how that can poſſibly be, upon the ſuppoſition of the earth's motion.

THE phenomena of bodies moving in the ſame direction with the abſolute motion of the earth, may be comprehended. The motion of bodies croſſing the abſolute motion of the of the earth is alſo intelligible, as repreſented and explained by a ſuppoſed diagonal of the two powers. But however well a perſon may be diſpoſed to embrace that doctrine, it is no eaſy matter to ſatisfy ones ſelf about the phenomena of bodies moving weſtward, or in an oppoſite direction to that of abſolute motion. If we ſhould ſuppoſe that a gun-ball fired point blanch weſtward, does not really move weſtward, but is only reſiſted by the exploſion from moving ſo faſt eaſt as the earth goes in her abſolute courſe; may it not be aſked, What is it that keeps the ball ſuſpended while the earth proceeds on in its abſolute motion? For the reſiſtance given to the abſolute progreſſive motion of the ball, can be no reſiſtance to its following the courſe of its gravity; as we know of no example to illuſtrate or explain to us, how reſiſtance applied horizontally will prevent a body from falling down to the ground for a longer time, than it would take to fall if it were not reſiſted horizontally. If the abſolute motion of a projectile in ſpace, is only the momentum of its *vis inertiæ* derived from the earth's motion; and if its apparent motion in a contrary direction is only the momentum of another *vis inertiæ* derived from the exploſion; what poſſible conception can be framed of two oppoſite *vis inertiæs*, acting ſo as to prevent the body for ſome time from purſuing the courſe of its gravity.

On the other hand, if relative motion weſtward is *real*, it ſeems to imply a plain contradiction; for no body can be ſuppoſed to move really eaſtward and weſtward at one and the ſame time.

But tho' the temporary motion of projectiles, which by the action of gravity are ſoon reſtored to the earth again, in order to partake afreſh of the momentum of the earth's abſolute motion, could be clearly accommodated to the doctrine of that motion: Yet how ſhall we apply it to ſelf-moving bodies? This momentum of abſolute motion, which all bodies are ſuppoſed to partake of, is not alledged to be maintained in them after they are ſeparated from the earth, by any other means than their *vis inertiæ*, or their retaining the quantity of motion once impreſſed on them. Now, no body can move itſelf in a direction oppoſite to its *vis inertiæ*, until that is overcome. How is it conceivable then, that birds, for example, after they are ſeparated from the earth, where they acquired their abſolute motion, ſhould ſtill retain it all. Certainly every reluctation of theirs, in an oppoſite direction, while upon the wing, muſt deſtroy ſome part of their abſolute motion, ſeeing theſe efforts have nothing to overcome but the quantity of abſolute motion they are in; for they are not ſuppoſed to have any freſh momentum of abſolute motion communicated to them, after they are lifted up from the earth. After they are aloft therefore, it is obvious they have it in their power to react, and deſtroy ſome of the momentum of their abſolute motion or *vis inertiæ*. This reaſoning, which I can perceive no fallacy in, implies a great change of the phenomena, in regard to the motion of ſelf-moving bodies; and yet in fact, as I have already obſerved, all the phenomena of motion are the ſame as if the earth were at reſt. In ſhort, this abſolute motion which bodies partake of with the earth, is ſomething which no re-action has any effect upon, and therefore we muſt conclude, it does not, it cannot depend upon the axioms of the preſent philoſophy; elſe, by the rule of theſe very laws of motion, real re-action would have a ſenſible effect in deſtroying it.

I SHOULD be extremely glad on my own account, as well as on account of others, who may be embarraſſed with the doctrine of theſe two motions, if I could in any meaſure clear them up; But I may be well excuſed from underdertaking it, if I can be as eaſily excuſed for offering a conſideration or two, without including which in attempting the ſolution of this doctrine, I apprehend it abſolutely unſearchable. Whether they will throw any light upon it, I leave to the conſideration of others.

Firſt, I SUPPOSE, that if this earth moves, the atmoſphere in which it is incloſed or immerged, and to which as a medium, I preſume, all other bodies owe their powers and phenomena of motion, moves along with the earth as if it were one body therewith, and that the earth does not move thro' it: Or, in other words, the materials of the atmoſphere, in all the earth's motion, preſerves the ſame abſolute ſtructure in relation to the earth, however within itſelf it may be topically formed into different climates, upon the earth's ſurface. This is in ſome reſpect ſelf-evident, upon conſidering the earth's diurnal motion: For if the atmoſphere were not ſtationary, but the earth moved through it, it would follow of conſequence, that once in twenty-four hours we would paſs thro' all the different climates round the earth which belong to the ſame latitudes; and theſe are known to be very various. Therefore I apprehend the atmoſphere is connected with the globe in the ſame manner as the ocean is with the land; and the motion of bodies in it is analogous to the motion of fiſhes in the waters.

This does not prevent every particular body from enjoying its own individual modification of the general atmoſphere of the earth, which is proper to it wherever it moves, and to which, it may be ſuppoſed, is owing the phenomena of that abſolute and relative motion obſerved in ſhips and other large moving bodies. A proof of this individual modification, in relation to all particular bodies, we have in the loadſtone, electrical and other bodies, which diſcover any very ſingular phenomena or virtues in their natures, which exert themſelves without the ſpheres of the bodies themſelves. If I may be indulged in a very groſs compariſon, for giving an idea of the general atmoſphere of the earth, and the individual atmoſphere peculiar to every particular body in it; I would compare it to the gummy incloſure which lint, creſſes, and other mucilaginous ſeeds acquire by infuſion in water.

Again, I am much inclined to believe, that what we call gravity, and the ſuppoſed abſolute motion of bodies, which belong to the earth, are nothing different. It is evident in the motion of projectiles and ſelf-moving bodies weſtward, which, notwithſtanding all that can be ſaid, muſt be real as well as relative, gravitation alone is ſufficient to preſerve any of the abſolute motion from being loſt by a real one in an oppoſite direction. I am perſuaded, if ſuch an impoſſible thing may be ſuppoſed, that if a body which never had been upon the earth to acquire its abſolute motion, were introduced as near to the earth, as the greateſt height to which any earthly body ever was projected, and there dropt, it would fall as perpendicular to the place it was over when let go, as any other body would do, which deſcended in conſequence of its being thrown up from the earth. I own indeed, that this is in effect ſuppoſing, that the principle of gravity is a ſphere which, in its different parts, uniformly preſerves its relation to the parts of the earth directly under it, or in a line with it. But I am apt to think, if experiment could be made of it, this alſo would be found to be the nature of the magnetic attraction, ſo far as its ſphere of action extends. If it ſhould be alledged, that by this way of reaſoning, I reſolve the principle of gravity and the atmoſphere into one and the ſame thing; I can only anſwer, that I can make no more of ſo dark a ſubject at preſent. This however, I am pretty clear upon, That as there is real motion in a contrary direction to that of abſolute motion, and as no body can really move in oppoſite directions at the ſame time, at leaſt not without the intervention or aſſiſtance of a medium, which partakes of the abſolute motion of the earth; ſo neither can this ſuppoſed abſolute motion be diſtinguiſhed from the tendency of gravitation. Again, I think it muſt be inconteſtible, that all real motion, not in the direction of abſolute motion, muſt deſtroy in whole or in part, that abſolute motion which is preſerved by no power but that of the *vis inertiæ*.

Now when we come to apply the theory of abſolute motion to the ſatellites, in whatever light we can attempt to conſider it, it becomes a matter abſolutely inconceivable, nay impoſſible. In the firſt place, we know of no abſolute motion communicated from greater to ſmaller bodies, but where they are ſo intimately connected that gravitation can at laſt, and that ſoon, overcome all their relative or projectile motion: But ſuch is the ſituation and diſtance of the moon, in regard to the earth, and ſo remote is their connection, that the moon's ſuppoſed gravitation never has gained any thing upon her projectile motion.

Secondly, We know of no abſolute motion communicated from greater bodies to ſmaller ones, but where the bodies are known to have been in original contact, by means of their gravity, when they were firſt projected or put in motion; ſo that their firſt motion muſt have been as one great body, and the relative motion muſt have been begun afterwards. But we have no reaſonable foundation for even preſuming that ever the earth and the moon were ſo connected; and if they ever had been ſo connected, by all the laws of projection and gravitation we have given us to judge of, we can conceive no projection which could be made that gravitation would not ſoon deſtroy, and reduce the projected body again to its ſtate of ſimple abſolute motion, along with the larger body.

Thirdly, THE moon, or any ſatellite, ſuppoſing their preſent diſtance to be their original one from the primary, could never, by means of the ſuppoſed weak connection of gravitation, correſpond with the projection of the earth, ſo as to partake of her abſolute motion. Let us ſuppoſe the moon placed at her preſent diſtance, and behind the earth, directly in the courſe of the earth's projection; in this ſituation, the moon being diſpoſed to advance towards the earth at the ſlow pace of ſixteen feet in a minute; at the ſame inſtant ſuppoſe the earth is projected away from the moon with the velocity of near a thouſand miles in the ſame time that the moon would have advanced ſixteen feet towards the earth: Can any perſon once ſuppoſe, that that imperceptible diſpoſition in the moon to join the earth, in her projectile or abſolute motion, would draw the moon into the momentum of the earth's abſolute motion. This ſuppoſition is attended with the ſame manifeſt impoſſibilities, in whatever part of her area the moon can be conſidered at the moment of projection. If we ſuppoſe her in, or nearly approaching to, her firſt quadrature, then the gravitation between them, and the projection of the earth, lying nearly in the ſame direction, nothing could prevent their joining and colliſion in a few hours; for at that time, their mutual gravitation could have no effect in communicating the abſolute motion of the earth to the moon, until they had met. The ſuppoſing that the projection of the moon round the earth commenced at the ſame inſtant with the projection of the earth, can in no degree render theſe impoſſibilities more accountable: For as it is not that projection which gives the moon her abſolute motion, the whole apparent impoſſibility of the theory remains; and I may ſay, is renewed in every ſuppoſable circumſtance every lunar month. For all the difficulties which attend the ſuppoſition of the moon's firſt conceiving her abſolute motion in this manner, caſt up in every courſe of the moon, and render it as impoſſible to ſuppoſe the moon's abſolute motion can be maintained by ſuch means, as it is that it could commence by them.

Fourthly, IT is no leſs impoſſible, that the moon's abſolute motion can be owing to a projection given herſelf, than that it can be owing to her gravitating connection with the earth, for this plain reaſon: Becauſe the moon has, or is ſuppoſed and allowed to have, a projectile motion quite different from this, namely, her motion round the earth. But nothing in nature can be conceived more impoſſible, I believe every mathematician will allow, than for a body to move in two projectile directions at one and the ſame time. If five hundred projections, all in different directions, were applied at the ſame time, the projectile would fall into one courſe common to them all; but it is merely impoſſible, that more than one courſe can be produced, by any, either multiplicity, or repetition of projections;

jections; unleſs the repetitions are momentarily renewed without end.

ADD to all this, if it is true, that there can be no real motion in an adverſe direction to abſolute motion, unleſs there be either a deſtruction or weakening of that *vis inertiæ*, which is the ſuppoſed principle for continuing abſolute motion, then the projectile courſe of the moon round the earth, muſt ſoon exhauſt and deſtroy her abſolute motion. For every lunar month, the moon, for no leſs than the extent of four hundred and eighty-eight thouſand miles, ſtruggles in a courſe, which is in effect, diametrically oppoſite to the momentum of abſolute motion, or of the *vis inertiæ* carrying her in another direction; and this cannot happen without weakening and at laſt ſuppreſſing the whole momentum of the *vis inertiæ*.

FOR theſe reaſons, unleſs I can ſee them fairly removed, I muſt conclude, that even ſuppoſing theſe principles of the *vis inertiæ*, gravitation, projection, &c. aſſumed by the preſent philoſophy, are real, yet it is impoſſible to explain the celeſtial motions by them, without introducing ſome further principle of *reſiſtance* alſo; which both prevents the planets from receding, and likewiſe from approaching nearer other than they do; and which acts as certainly in that manner, as the line does in the caſe of the ball vibrating or moving round by its means, or as a ball rolls in a bowl or hollow ſphere.

Upon the whole, I conclude, There are only two powers within the compaſs of human conception, which can be conſidered ſufficient to produce and maintain theſe lofty and intricate revolutions performed by the heavenly bodies. Theſe are, either the direct and immediate efficacy of an omnipotent thinking agent, who can vary and bend the motions of all the orbs uninterruptedly according to his will, and with infinitely more eaſe than a man can move his hand, and whatever he holds in it, in any direction he he pleaſes: Or, an inconceivably ſubtile and profound combination of mechanical powers, executed by that ſame artiſt who gives being and ſtructure unerringly to every thing after its kind.

An Examination of the firſt Lemma of Sir Iſaac Newton's Principia.

As Sir *Iſaac Newton* propoſes to demonſtrate his principles by the method of *firſt and ultimate ratio's*, this method of demonſtrating ought to be examined, for if the method itſelf prove fallacious, it is certain that all the demonſtrations built upon it, muſt fall to the ground.

Sir Isacc's firſt lemma is, That quantities, and alſo the ratios of quantities, which conſtantly tend towards equality in any finite time, and before the end of that time approach nearer to each other, than for any given difference, becomes ultimately equal.

If you deny this (ſays the author) let them be ſuppoſed ultimately unequal, and let their difference be D, they cannot therefore approach nearer to each other than the ſuppoſed given difference D: But this is contrary to the hypotheſis.

But is not this a falſe method of arguing? Suppoſe I cannot aſſign the difference between two quantities, will that prove them equal? It certainly will not; it will only prove, that the difference is too minute for my ſenſes to meaſure and determine; if this lemma was to be admitted, it would prove that all quantities which are either ſo ſmall as to elude the ſenſe, or ſo large as to be incomprehenſible, or incommenſurable by it, muſt be therefore equal, but ſuch a poſition is evidently abſurd; it is certain therefore, that the difference of quantities does not depend upon our power to aſſign or determine the difference, but upon the quantities themſelves; there may be a real difference between quantities, tho' we cannot determine it, as on the other hand quantities may be equal, which we cannot prove to be ſo, becauſe we cannot aſſign their meaſures.

But it may be ſaid, that Sir *Iſaac* ſuppoſes the quantities to be conſtantly tending towards equality, but this ought to be expreſſed with more preciſion; for it is certain, that quantities may tend towards equality in ſuch a manner that they never will become equal: On the other hand it is granted, that quantities originally unequal may tend towards equality in ſuch a manner, as to become very ſoon equal: For inſtance, ſuppoſe, two lines, the one 12 inches, the other 6, to be both perpetually diminiſhed by one half in equal times; it is obvious that theſe lines are conſtantly tending towards equality, yet they never will become equal. On the contrary, they will always preſerve their original proportion to each other, tho' the difference between them will be perpetually diminiſhing; thus, the difference at firſt is 6 inches; the firſt biſection reduces the difference to 3 inches, but their proportion is not altered; the one is ſtill double of the other: The ſecond biſection reduces the difference to one inch and a half, but the proportion remains unaltered; the one is ſtill double of the other. In ſhort, if we continue the biſection without end, according to the mathematical doctrine of the infinite diviſibility of matter, it is certain, that the difference between theſe two quantities may be diminiſhed ſo as to become leſs than any given difference, and yet the original proportion remain unaltered, ſo that the one quantity ſhall be always double of the other; but it would be abſurd to ſuppoſe, that one quantity ſhould be double of another quantity, and at the ſame time equal to it.

On the other hand, if we ſuppoſe theſe quantities, of 12 and 6, to be unequally diminiſhed, the greater being diminiſhed by 8, while the leſſer is diminiſhed by 2, this will preſently reduce them to equality; but then it is plain, that the quantities are not proportionably diminiſhed. In ſhort, this lemma of Sir *Iſaac*'s is ſo far from holding univerſally true, that it is plain it never can take place, in quantities either equally diminiſhed or augmented; for while the one quantity is diminiſhed or augmented in the ſame proportion as the other, their proportion to each other remains unaltered, and if that proportion was originally any proportion of inequality, it muſt remain perpetually the ſame, and never can be converted into the ratio or proportion of equality.

As to the quibble founded on the impoſſibility of aſſigning the ultimate difference between quantities perpetually diminiſhed or increaſed, that it is no more than a quibble may be proved by applying it to the caſe of the hyperbole and its aſymptote; it is well known that the property of theſe lines is ſuch, that tho' they perpetually approach each other, yet they never will coincide; this is demonſtrated geometrically, and is, I believe, among other arguments adduced by the mathematicians to prove the infinite diviſibility of matter; but if we admit the method of proof uſed by Sir *Iſaac*, we muſt ſet aſide this property of the hyperbole and its aſymptote, for as theſe are perpetually approaching to each, ſo if infinitely produced, their diſtance muſt ultimately become leſs than any poſſibly aſſignable diſtance, therefore they muſt ultimately coincide; if you deny it, let their ultimate diſtance be D, they cannot therefore approach nearer than the diſtance D, which is contrary to the hypotheſis; this reaſoning is *mutatis mutandis*, preciſely the method of proof uſed by Sir *Iſaac*, and as it directly contradicts a geometrical demonſtration, it is ſurpriſing how it ſhould be admitted by geometricians.

IT would be tedious to undertake a particular examination of all the ſubſequent lemmas of this celebrated author. It is plain, that as far as they depend upon the firſt, they ſtand or fall with it; but it is neceſſary to take particular notice of the ſeventh lemma, and the third corollary deduced from it. The lemma is as follows: The ſame things being ſuppoſed (alluding to the preceding lemma) I ſay, that the ultimate ratio of the arc, chord, and tangent to each other, is the ratio of equality.

THE third corollary drawn from this lemma is, that in all reaſoning concerning ultimate ratio's, all theſe lines, (viz. the arc, chord, or tangent) may be indifferently uſed for each other.

I SHALL omit the examination of the author's demonſtration, becauſe I apprehend, it may be demonſtrated geometrically, that the ultimate ratio of the chord, arc, and tangent, neither is, nor can be the ratio of equality; and it would be abſurd to ſuppoſe, that geometry can demonſtrate two contradictory propoſitions to be both true. The demonſtration that the ultimate ratio of the chord, arc, and tangent, cannot be the ratio of equality, is as follows.

It is known, that it is impoſſible to draw two right lines which ſhall both touch the ſame circle in one and the ſame point; it is alſo certain that the angle of contact, formed by the tangent and periphery of the circle, at the point of contact, is leſs than the leaſt poſſible rectilinear angle; it is alſo certain, that thro' the point of contact different circles may be drawn, each of them forming angles of contact with the ſame right line, which will be leſs and leſs, as the radius is increaſed, tho' the greateſt of theſe angles of contact is leſs than the leaſt rectilinear angle which can poſſibly be drawn.

These things being allowed, ſuppoſe a circle drawn with any radius, let us call it A, and let it be touched by a right line in a point C, the angle of contact at C, is acknowledged to be leſs than any rectilinear angle which can poſſibly be drawn; thro' the point C, let a ſecond circle be drawn with a greater radius, ſo as it may be touched in the point C with the ſame right line, which touches the firſt circle A in the ſame point; call this ſecond circle B; it is plain, that the angle of contact formed by the tangent and the periphery of the ſecond circle B, is leſs than the angle of contact, which the ſame tangent forms with the periphery of the firſt circle A. Now, ſuppoſe the arc of the ſecond circle B, to be diminſhed towards the point C, till it becomes, in the ſtile of the mathematicians, infinitely ſmall, let the tangent be diminiſhed towards the ſame point, in the ſame manner, we will then have an infinitely ſmall arc, and an infinitely ſmall tangent, touching each other, and alſo another circle A, in the ſame point C; according to Sir *Iſaac*, the ultimate ratio of the infinitely ſmall arc of the circle B, and of the infinitely ſmall tangent, are the ratio of equality, and the arc and tangent may be uſed for each other; of courſe, the infinitely ſmall arc of the circle B, will become a right line; and we will have two different right lines, both touching the ſame circle A, in one and the ſame point C; and we will alſo have a rectilinear angle, leſs than the angle of contact formed by the tangent with the periphery of the circle. But both theſe are impoſſible, and therefore it muſt be impoſſible that the ratio of the tangent and of the arc of the circle B, let them be diminiſhed in what manner you pleaſe, can ever become the ratio of equality.

THE corollary is obvious, that therefore in no kind of reaſoning, The chord, arc, and tangent, can ever be uſed indifferently for each other; right lines and circular lines are lines different in kind, which have different properties, and diminiſh them at pleaſure, even to a mathematical point, yet each of them in that ſtate of diminution retains their ſpecific properties, unaltered and unchanged; they cannot therefore be uſed indifferently, and all reaſoning, which is founded upon uſing either the chord or tangent for the arc, or *vice verſa*, the arc for the chord or tangent, muſt be fallacious and illuſory.

FINIS.

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